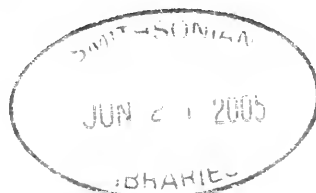


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A New and Unusual Species of Stephanidae (Hymenoptera), with a Discussion on its Phylogenetic Implications

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Abstract.—*Megischus basalis* sp. n. is described from male specimens collected in Guatemala and misidentified in the literature as *M. annulator* Brullé. The new taxon is incompatible with all genus-level schemes proposed in the literature and is tentatively interpreted as the most basal species of the *Megischus*-complex, immediately apical to *Stephanus* s. s., representing an entirely new step to be considered in the phylogeny of the family. The new taxon illustrates the difficult interpretation of aberrant stephanid species, suggesting that such taxa should not be assigned to new genera without a formal cladistic analysis.

The Stephanidae are one of the smallest families of Hymenoptera, with 326 valid species worldwide (Aguiar 2004b). Thus, it is perhaps surprising that the corresponding literature is permeated with increasingly dissident opinions about its genus-level classification (e.g., Schletterer 1889, Enderlein 1905 and 1906, Elliott 1922, Ceballos 1926, Townes 1949, Orfila 1956, Benoit 1951, DeSantis 1980, Achterberg 2002). There is a varying number of genera recognized, and each of them is often differently delimited by each author. This situation indicates that a rigorous cladistic analysis of the family is urgently needed.

Examination of stephanid specimens for a distinct study (Aguiar 2004a), revealed a remarkable undescribed species of key importance to the phylogenetic interpretation of the family. The aim of the present work is to name and describe this new taxon, discussing the phylogenetic implications of its unusual morphology for the phylogeny of the family.

Morphological terminology and generic concepts follow Aguiar (2001). For the phylogenetic discussion, data from Aguiar (2000) was compared with *Megischus ba-*

salis sp. n., *Protostephanus ashmeadi* Cockerell (examined; extinct), *Electrostephanus neovenatus* Aguiar and Janzen (examined; extinct), and *E. brevicornis* Brues (literature data; extinct). Drawings were prepared by Gláucia Marconato, under the author's supervision.

Megischus basalis Aguiar, new species (Figs 1–10)

Megischus annulator Brullé (part): Cameron 1887: 419; ♂ pl. 18, fig. 7, ♂ pl. 18, fig. 8. Listed, male description, distribution record, figure.

Type material.—3 ♂♂, corresponding to the specimens described by Cameron (1887). Holotype (BMNH) from Guatemala: "S. Geronimo, Guatemala. Champion.", "1", "P. Cameron Coll., 1914–110.", "OSUC0022919" (barcode, plastic). Conditions: antennae, except left scape and pedicel, front tarsi and most of remaining tarsomeres, lost; wings partially destroyed; covered by some dirt and fungi. Paratypes 2 ♂♂ (BMNH) Guatemala: "S. Geronimo, Guatemala, Champion.", "P. Cameron Coll., 1914–110.", "OSUC0022917" (barcode, plastic). Conditions: antennae, front and mid legs, and all wings, lost. "San Geronimo, Vera Paz. Champion.", "B. C. A.

Hymeno.I., *Megischus annulator* Brullé.", "OSUC 0022918" (barcode, plastic). Conditions: antennae, left tibia and tarsi, and left wings, lost.

Description.—Male. *Head*: Frons strongly transverse rugose ventrally, then suddenly longitudinally rugose dorso-laterally. Vertex glabrous, with 3–4 concentric interocellar carinae; irregularly rugose behind them; antero-laterally strongly longitudinally rugose, changing to uniformly and transversely rugose centrally and posteriorly, including post-vertex, and reaching occipital carina (Fig. 1). Temples and gena polished, smooth; gena projected laterally, forming a conspicuous callosity (Fig. 1). Occipital carina dorsally narrow or linear, becoming moderately wide laterally, and then again narrow ventrally; apically with each side reaching, but not touching, the hypostomal carina, then curving outwards and extending briefly along it. Hypostomal carina linear, not forming a flange. *Mesosoma*: Pronotum short, colo slightly longer than semiannular; anterior margin uplifted and slightly turned backwards, distinctly emarginate, but concavity not deeper than wide (Fig. 3). Colo dorsally without, or with an inconspicuous depression dorso-centrally; about 4 complete carinae plus some 4 other incomplete, all regular looking, none wide or leaf-like (Figs 2–3). Pronotal fold indistinct, its position indicated by the semiannular, which raises suddenly (in lateral view, with a distinct step between these structures) (Fig. 2). Preannular not differentiated. Femoral sulcus entirely distinct and well-marked, subcrenulate or distinctly crenulate (Fig. 2). Ventral area distinctly longitudinally striate (Fig. 2). Semiannular latero-centrally mostly smooth, with several very small punctures, dorsally, and laterally in front of the pronotal lobe, strongly transversely rugose (Figs 2–3). Prosternum with a distinct depression centrally subapically; mostly polished, smooth, but with medium-sized shallow punctures and micropunctures, both more frequent toward

the external margin of each hemisternite; apex and latero-basal angles rugulose. Mesepisternum covered with sparse shallow foveolation and micropunctures; polished, smooth between foveae; dorsal part distinctly transversely striate; pilosity sparse, associated with foveolae, but dense, delicate pilosity on dorsal part. Mesopseudosternum glabrous, perfectly polished, smooth; discrimen distinctly and entirely foveolate. Hind coxa with delicate sculpture and hairs; dorsally finely transversely rugulose, with a small microreticulate area dorso-laterally; ventrally mostly polished, smooth; mesally alutaceous and with longer and more dense pilosity. Hind femur glabrous, except for hairs on apex of each ventral tooth or tubercle; entirely coarsely alutaceous, matt; with two to several conspicuous denticles basad of central tooth, which is placed beyond the middle. Hind tibia posteriorly very slightly compressed centrally, forming a small callosity; otherwise simple, straight; ventro-longitudinal carina differentiated along compressed part only, although advancing a little over dilated part. Hind basitarsus cylindric, elongate; fourth tarsomere with ventral side greatly projected, almost reaching apex of fifth tarsomere. Propodeum centro-longitudinally transversely striate, laterally, including flanks, more finely, irregularly and obliquely striate, in some parts changing to rugose or rugulose; also with some small areolations, particularly on the sides of the centro-longitudinal strigation (Fig. 5). Parapetiole depression shallow and mostly polished, smooth, with 1–2 transverse subcrenulations or incomplete carina. Spiracular groove not defined, entirely absent, or inconspicuously indicated by 1–2 short longitudinal rugosities (Fig. 5). Interfoveolar and postfoveolar areas distinctly transversely carinate or crenulate; pleuropropodeal fovea not clearly delimited; postfoveolar area continuous with metasternum, and distinctly projected ventrally over the base of mid coxa, form-

ing a lobe (Fig. 4). Metapleuron dorsally and ventrally mostly or entirely polished, smooth; laterally coarsely and subtransversely rugose, with sparse long hairs but without pruinosity. *Wings*: venation intermediate between that of *Stephanus* and *Schlettererius*, as follows. Front wing (Fig. 9) with a long parastigma, vein 1M distinctly arched, 2r unusually short, and 2-1A apical half nebulous. Hind wing (Fig. 10) with anterior and posterior folding lines distinct; veins Sc+R and M+Cu basally tubular; remaining of M+Cu, and all of 1M, 1r-m, 1Rsb, 2M, and Cua nebulous; Cua forwardly oblique; veins 1Rsb and 2M ending near wing margin; vein 1M longer than Cua. Three apical hamuli. *Metasoma*: Petiole wide, $4.0\times$ as long as maximum dorsal width (Fig. 6); dorsally, at base, rugose (Fig. 7), then transversely rugulose, changing to almost polished, smooth apically; shape characteristic, very large at base and largest at point of articulation with second tergite, its apical margin straight (Fig. 8); changing from cylindrical basally to somewhat flattened apically; spiracular tubercles distinctly visible from above, situated distinctly basad of middle (Fig. 6). Remaining tergites polished, smooth, but second tergite basally with strong rugosity (Fig. 8). *Coloration*: Body, including head, dark brown; malar space with a distinct yellow spot; front and mid legs brown with reddish or yellowish hue; apex of hind femur, hind tibia entirely, or at least its dilated part, and hind tarsus, light brown or amber yellow. Front and hind wing membrane amber yellow, veins brown.

Female.—Unknown.

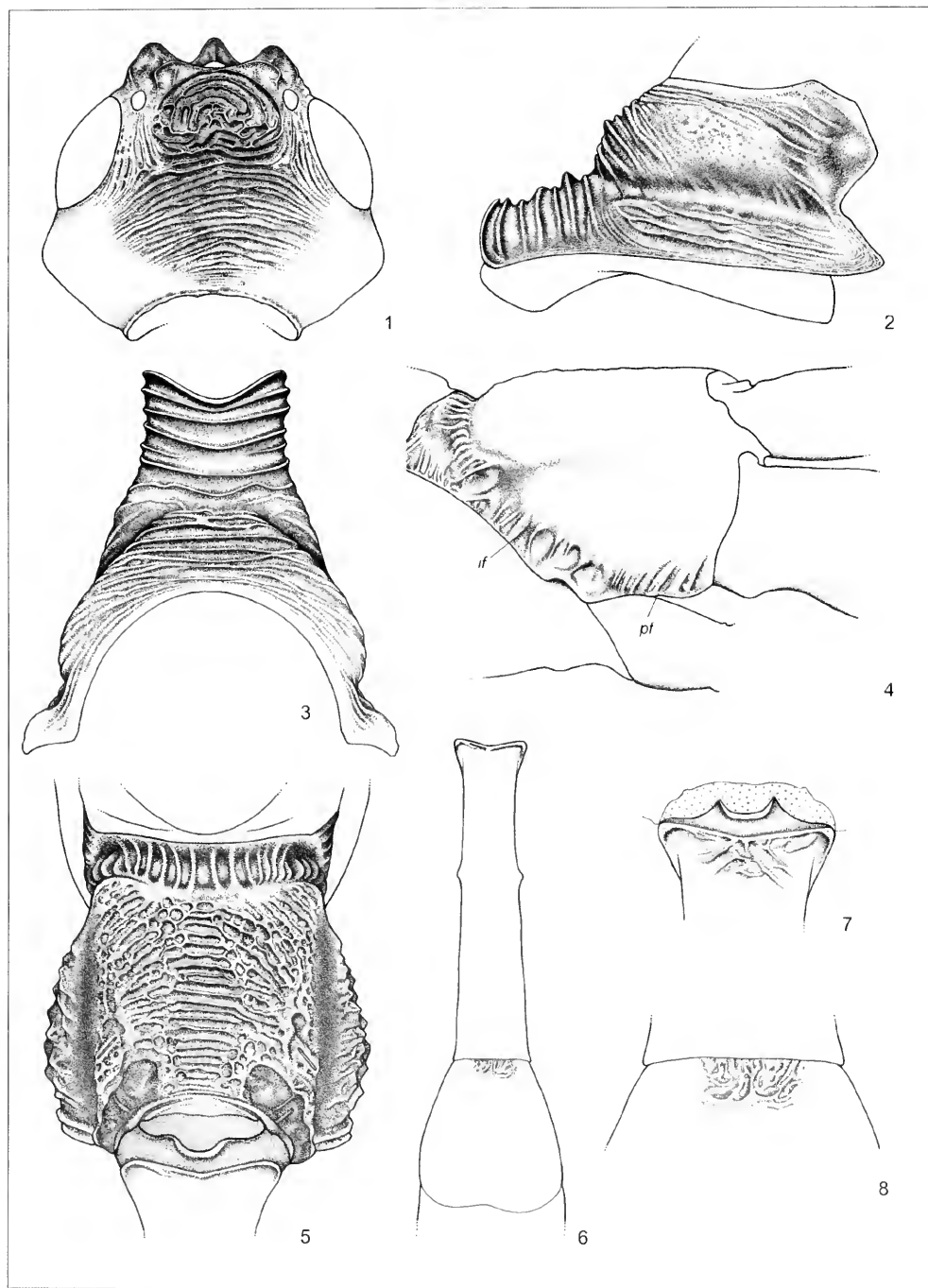
Comments.—The type specimens of the present species were originally described by Cameron (1887) as the male of *M. annulator* Brullé, 1846, now a junior synonym of *M. furcatus* (Lepeletier and Serville, 1825). Although not discussed by Cameron, the respective female was also illustrated, and its front and hind wing venation, head and metasoma indicate it

represents a typical *Megischus*, possibly *M. furcatus*. The male specimens, however, belong to a very distinct species, clearly isolated from all other American Stephanidae, including *M. furcatus*, a valid species for which the male is well known. *Megischus basalis* sp. n. is easily separated from all other American species by the overall structure of pronotum, preannular area absent, hind wing vein 1M remarkably long, hind wing vein Cua defined, nebulous, inclined toward wing apex, propodeum strongly striate centrally to areolate laterally, hind femur glabrous, entirely and strongly alutaceous, hind tibia light brown or yellowish, petiole shape unique, especially by unusually wide base and apex, and by the second metasomal tergite basally with strong rugosities, smooth otherwise. The overall head sculpture, with a central, a latero-longitudinal and a postero-transversal pattern, is also characteristic.

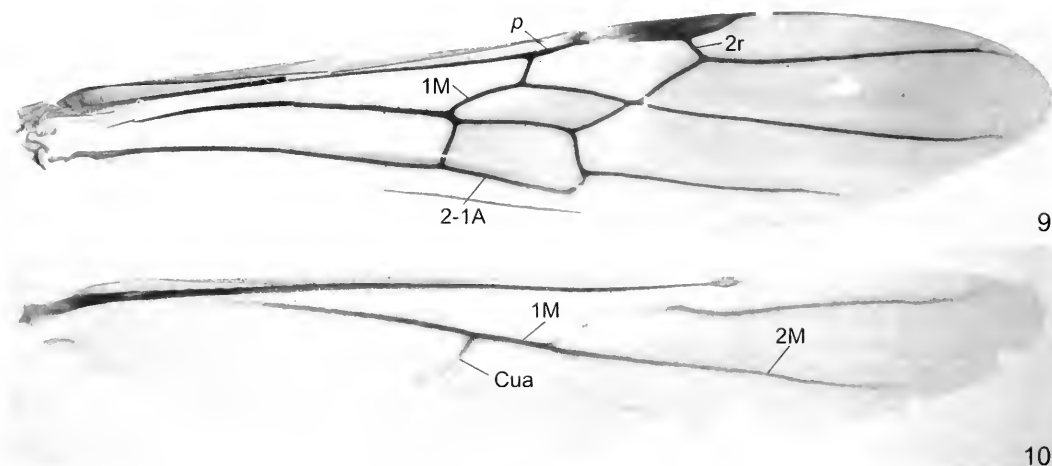
The types of *M. annulator* Brullé were not examined, but its original description mentions that, in the metasoma, “le deuxième segment est luisant et offre tout au plus une ou deux rides à la base” (second metasomal tergite shining, at most with one or two wrinkles basally); this is similar to what is observed in *M. basalis* sp. n., but the basal rugosity is much stronger for the latter (Fig. 7). Brullé (1846) also mentions, in the same description, a “métathorax parsemé de quelques gros points, ridé en arrière et un peu au milieu” (propodeum with some large foveae, wrinkled behind and a little centrally), decidedly unlike the dominant and complex striate-areolate pattern, without isolated foveae, covering the entire propodeum of the examined specimens (Fig. 5). Moreover, the above features of *annulator* fit well the condition observed for both sexes of *M. furcatus*.

Distribution.—Guatemala.

Discussion.—Although known only from males, which in Stephanidae are not as characteristic or informative as females,



Figs. 1–8. *Megischus basalis* Aguiar, new species. Holotype ♂. 1, Head, dorsal. 2, Pronotum, left. 3, Pronotum, dorsal. 4, Interfoveolar (*if*) and post-foveolar (*pf*) areas, left. 5, Propodeum, dorsal. 6, First and second metasomal tergites, basal. 7, First metasomal tergite basally. 8, Second metasomal tergite basally, detail. Drawings by Gláucia Marconato.



Figs. 9–10. *Megischus basalis* Aguiar, new species. Holotype ♂. 9, Front wing (*p* is the parastigma). 10, Hind wing. Illustrations not to scale.

M. basalis sp. n. displays an important combination of features which, taken together, may challenge definitions for some supraspecific taxa of the family. First, it displays features which are at the same time typical of *Schlettererius* (gena protruded, small eyes, pronotal fold absent, petiole smooth, front wing crossvein 2r very short, vein 1M arched, and hind wing venation well developed, with a distinct Cua) and *Stephanus* (pronotal structure, front wing parastigma very long, vein 2-1A nebulous only apically, hind coxa without a meso-dorsal tooth, moderately long petiole, and its tergite and sternite completely fused), suggesting that *M. basalis* could be an intermediate taxon between these two genera, and therefore basal to *Megischus*. However, *M. basalis* also shows features which are characteristic of *Megischus*, or of other more derived taxa, such as an elaborate propodeal structure and sculpturing, and the hind tibia narrowed basally and dilated apically. When further combined with a hind coxa as long as, or slightly longer than maximum length of mesepisternum, and the petiole distinctly longer than second metasomal tergite, *M. basalis* is also easily isolated from the extinct *Protostephanus* Cock-

erell and *Electrostephanus* Brues s. s. Finally, *M. basalis* also does not show any of the presumed synapomorphies for *Hemistephanus* or more derived groups, either as defined by Aguiar (1998, 2001) or Achterberg (2002).

Thus, evidence support *M. basalis* as one of the oldest existing stephanids. However, while it lacks most of the derived features of *Megischus*, it does have a few of them, which is enough to indicate a next evolutionary step in relation to *Schlettererius* and *Stephanus*. Therefore, it is reasonable to assume that *M. basalis* is, in fact, an intermediate form between *Stephanus* and *Megischus*, representing an entirely new step to be considered in phylogenetic interpretations of the family. Its current placement in *Megischus* is based on the fact that if *Stephanus* is expanded to include some of the derived features of *Megischus* (i.e., those present in *M. basalis*), then these genera would become close enough to be synonymized, a clearly unstable taxonomic decision at this point.

Withal, *M. basalis* also shows unique features in Stephanidae, such as the second metasomal tergite basally strongly rugulose (Figs 6, 8), the complex structure of the inter- and post-foveolar areas (Fig. 4),

and, in particular, the hind wing with an unusually long vein 1M (Fig. 9). If compared to results in Aguiar (2000), the following features can also be recovered as likely apomorphies for *M. basalis*: frons with downwardly inclined hairs; vertex sculpturing transverse and parallel; colo with central depression; pronotal fold indistinct; vellum of antenna cleaner apically somewhat lobed; only 2 simple, and 1 hook-shaped hamuli; mesepisternum between mid coxae glabrous or nearly so; post-foveolar area not aligned with inter-foveolar area; and hind coxa and femur with minute decumbent hairs, which are much shorter than length of basal femoral tooth.

Although evidence suggests that *M. basalis* could perhaps be assigned to a new genus, it must first be considered that aberrant species in the family are, in fact, not uncommon, with extreme forms occurring even within limited areas throughout the world. This is further worsened by the fact that establishing even basic relationships of such "oddballs" with other stephanids is often an arduous task. Thus, while erecting new genera from such taxa is easy, it is not necessarily enlightening, and might expand the degree of confusion between genus-level definitions.

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Suzanne Lewis and Christine Taylor, at the Natural History Museum (London), kindly arranged for loans of all specimens studied here. This work benefitted from a scholarship from CAPES (Brazil) and from research funding provided by FAPESP (Brazil), paid directly to the author (Processes 00/05704-6 and 03/08585-6), or acquired from specific funds allocated to this work in a connected project of C. Roberto F. Brandão (FAPESP process 98/05083-0). Luciana Musetti, Eric E. Grissell and two anonymous reviewers contributed with valuable suggestions.

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Three New Species of *Masarina* Richards, 1962 from Southern Africa with a Key to all Species of the Genus (Hymenoptera: Vespidae, Masarinae)

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Abstract.—Descriptions are given of the following three new species of *Masarina* Richards, 1962, a genus endemic to southern Africa: *aptosimi* (♀, South Africa), *hermanniae* (♀ and ♂, South Africa), and *roberti* (♀, Namibia). Flower associations are given for all three species. The key to species of *Masarina* given by Gess (1997) is presented in revised form to include the newly described species.

The genus *Masarina* was erected by Richards (1962) as part of his study of the Masarinae of the world. He recognized three species, all from southern Africa to which region the genus appears to be restricted. Since 1962 a further 10 species have been recognized, one by Gess (1988), six by Gess (1997) and three described in the present paper.

The distribution of *Masarina*, as presently known, is shown in Fig. 1. The type localities of the three new species are indicated by the initial letters of their names.

The notation used for expressing geographical co-ordinates is as in the gazetteer of *The Times Atlas of the World* (1981). The figures before the stop are degrees, those after the stop are minutes; the stop is **not** a decimal point.

The acronym AMG = Albany Museum, Grahamstown, South Africa

DESCRIPTIONS OF SPECIES AND COLLECTING DATA

Masarina aptosimi Gess, sp. nov.

Diagnosis.—Female: frons on each side with subtransverse, medially and laterally downcurved carina; sculpture of head and thorax coarse; body without any pale markings; terga I–III reddish-brown; wings very dark brown. *M. aptosimi* shares

with *M. peliostomi* Gess the frontal carinae (absent in all other known species of *Masarina*) but differs most strikingly from it in that the mesoscutum is coarsely reticulate punctate rather than largely impunctate and in that the gaster is partly reddish-brown rather than black with pale posterior bands.

Description.—*Female*: Black. The following are reddish-brown: mandible (distally); tegula (partially); terga I–III; sterna II and III (partially). Legs and wings very dark brown.

Length 7.8 mm; length of front wing 5.8 mm; hamuli 13.

Head $1.33 \times$ as wide as long (measured across eyes and from vertex to bottom of emargination of clypeus respectively). Clypeus markedly raised from sides, noticeably wide and short ($1.87 \times$ as wide as long, measured between lateral angles and from base to bottom of ventral emargination); disk evenly convex (not depressed or flattened); distal margin lamelliform and somewhat upturned, bilobed; lobes (disto-lateral corners) rounded and median emargination smooth, wide and deep; surface coarsely longitudinally reticulate punctate. Frons on each side in upper half with pronounced smooth transverse carina, the two carinae not meeting medially,

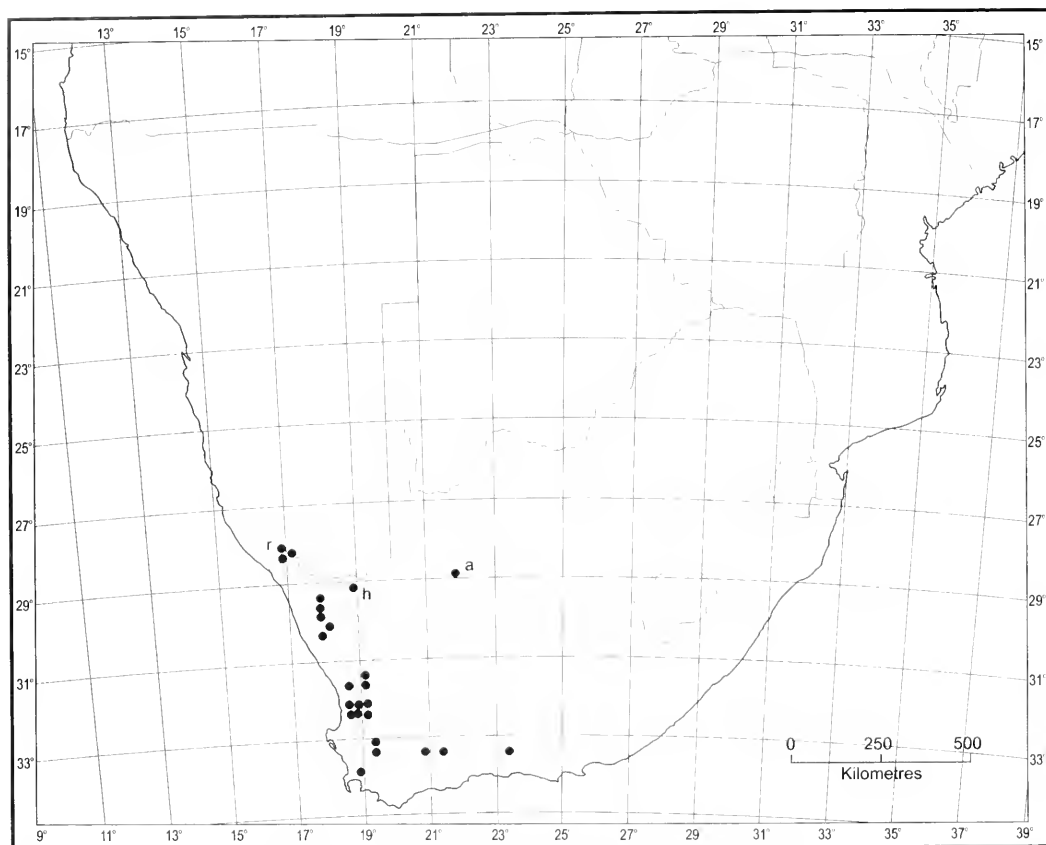


Fig. 1. Distribution of *Masarina* Richards, indicating the type localities of the three new species: a = *aptosimi*; h = *hermanniae*; r = *roberti*.

each laterally downcurved before reaching middle of upper part of eye and ending near bottom of ocular sinus; on each side in lower half with wider but less distinct carina originating medial to antennal insertion and curving upwards and outwards to end in ocular sinus; carinae very similar to those of *M. peliostomi* (illustrated in Gess 1997, Fig. 35); surface sculpturing in area below upper carinae like that of clypeus—coarsely longitudinally reticulate punctate, above carinae somewhat less coarse and progressively grading into finer sculpture of vertex and occiput.

Pronotum, mesoscutum, and scutellum coarsely reticulate punctate (mesoscutum postero-medially and scutellum longitudinally so); pleura less coarsely sculp-

tured; propodeum angled laterally, finely and closely punctured; terga I–VI with fine shallow punctures and microsculptured interstices.

Setae short and sparse everywhere.

Tegula 1.6 × as long as wide, basally widened, laterally smoothly curved to narrowed and incurved apex.

Front tarsomeres II–IV produced into inwardly directed lobes, that of II short, those of III and IV much longer, flattened, narrow and sub-parallel sided, that of IV reaching middle of V; middle tibia with two spurs; hind tibia with shorter (outer) spur simple and longer (inner) spur bifid.

Etymology.—The name *aptosimi*, genitive singular, is formed from the generic name of the plant, *Aptosimum* sp. (Scrophulari-

aceae), in the flowers of which the wasp was found foraging for nectar or nectar and pollen.

Material examined.—Holotype: ♀, SOUTH AFRICA: NORTHERN CAPE: 5 km NW of Groblershoop (28.52S 21.55E), 19.iv.1998 (F. W. and S. K. Gess) (visiting purple/violet flowers of *Aptosimum albomarginatum* Marloth & Engl., Scrophulariaceae) [AMG].

Discussion.—*M. aptosimi* and *M. peliostomi* Gess, both with frontal carinae, have as their forage flowers species of the very closely related genera *Aptosimum* and *Peliostomum* (Scrophulariaceae) which are not known to be visited by other species of *Masarina* but are typically visited by several species of another masarine genus, *Celonites* Latreille, 1802.

Masarina hermanniae Gess, sp. nov.

Diagnosis.—Both sexes: small (♂ 5.8 mm, ♀ 6.8 mm); terga predominantly reddish-brown (♀) or reddish-brown with black basal bands and yellowish-white posterior bands (♂); clypeus shallowly longitudinally depressed and aciculate; tegula yellowish-white, elongate and posteriorly acute. *M. hermanniae* shares with *M. familiaris* Richards, *M. hyalinipennis* Richards and *M. strucki* Gess the longitudinally depressed clypeus. It is most closely allied to *M. strucki* with which it has in common the marked longitudinal aciculation of the clypeus and the adjacent area of the frons but from which it is distinguished *inter alia* in size (in *strucki*, ♂ 6.6 mm, ♀ 7.5 mm) and colour pattern (in *strucki*, gaster of both ♂ and ♀ black with yellowish-white posterior bands; labrum, clypeus and frons of ♂ black, without yellowish-white markings).

Description.—*Female*: Black. The following are yellowish-white: small mark at bottom of ocular sinus; short streak behind upper part of eye; dorsal margin and humeral angle of pronotum; minute spot on mesopleuron below tegula; tegula (other than for medial testaceous area); apex

of scutellar disk; scutellar lamella; small marking postero-laterally on gastral tergum I. The following are various shades of reddish-brown: underside of flagellomeres II–VII (rest of flagellomeres dark brown); mandible (other than extreme base); entire gaster (other than for above detailed yellowish-white markings), with somewhat lighter diffuse transverse band between pale markings on tergum I and very narrow transverse posterior bands on terga II and III; distal part of femur, tibia and tarsus of all legs. Wings almost hyaline.

Length 6.8 mm; length of front wing 4.4 mm; length of extended tongue 3.3 mm; hamuli 9.

Head $1.15 \times$ as wide as long (measured across eyes and from vertex to bottom of median lobe of clypeus respectively).

Clypeus markedly raised from sides, $1.5 \times$ as broad as long (measured between lateral angles and along midline), widely and shallowly longitudinally depressed medially; distal margin trilobed; lateral lobes (disto-lateral corners) rounded and lamelliform; median lobe gently convex, raised above level of flanking lobes. Frons with lower third raised laterally, widely and very shallowly depressed medially to match form of clypeus; clypeus and frons both with scattered punctures and with surface markedly longitudinally aciculate; vertex behind eyes finely and closely reticulate punctate.

Pronotum, mesoscutum, mesopleuron and scutellum with punctures larger than on head, with smooth, shiny interstices; mesoscutum anteriorly with slightly impressed median longitudinal line; scutellum rounded, moderately raised above mesoscutum and anteriorly falling gently onto it; scuto-scutellar groove narrow, deep; propodeum very slightly angled laterally; terga I–VI progressively more closely and finely punctured.

Setae on clypeus and frons long, semi-erect, directed inwards towards midline, those on pronotum and mesoscutum

shorter, semi-erect, those on gaster short, sub-decumbent, posteriorly directed.

Tegula with lateral margin smoothly and evenly curved, inner posterior angle acute.

Front tarsomeres II–IV slightly produced but not forming inwardly directed lobes; middle tibia with one spur; hind tibia with shorter (outer) spur simple and longer (inner) spur bifid.

Male.—Black. The following are yellowish-white: clypeus (except narrow testaceous lateral and distal margins); large bilobed marking on lower half of frons; mark filling ocular sinus and variously extending upwards along inner margin of eye; streak behind upper part of eye; spot on underside of scape and (in one specimen) spot on underside of pedicel; dorsal surface of pronotum except variably sized postero-lateral area; variably sized spot on mesopleuron below tegula; tegula (other than for medial testaceous area); small spot on axilla; apex of scutellar disk; scutellar lamella; metanotum medially; propodeum dorso-laterally; posterior bands, not reaching lateral margins, on terga I–VI; that on I wide and only slightly expanded laterally and those on II–VI narrow but medially and laterally expanded. The following are various shades of reddish-brown: underside of flagellomeres; mandible (other than extreme base); diffuse transverse medial bands, reaching lateral margins, on terga I–VI; posterior half of tergum VII (in one specimen only); sterna generally; distal half of femur, tibia and tarsus of all legs. Wings almost hyaline.

Length 5.8 mm; length of front wing 4.2 mm; hamuli 7–9.

Structurally similar to female but differing in the following respects. Setae on clypeus and frons finer, less obvious; propodeum distinctly angled laterally, almost tuberculate; tergum VII with hind margin subtruncate (unlike rounded hindmargin of tergum VI of female).

Etymology.—The name *hermanniae*, gen-

itive singular, is formed from the generic name of the plant, *Hermannia* sp. (Malvaceae: Sterculioideae), in the flowers of which the wasp was found foraging for nectar or nectar and pollen.

Material examined.—Holotype: ♀, SOUTH AFRICA: NORTHERN CAPE: Aggeneys (29.14S 18.51E), 29.ix.2003 (F. W. and S. K. Gess) (visiting orange flowers of *Hermannia* sp., Malvaceae: Sterculioideae) [AMG]. Paratypes: 3 ♂♂, same data as holotype [AMG].

Discussion.—*M. hermanniae* like *M. strucki* forages in the flowers of species of *Hermannia*, a floral association different from that of other species of *Masarina*.

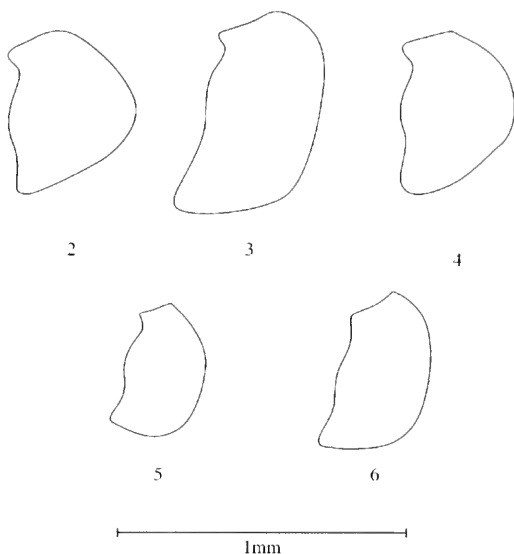
Masarina roberti Gess, sp. nov.

Diagnosis.—Female: small (6.0 mm); clypeus slightly flattened but not medially depressed; terga I–IV light reddish brown with pale postero-lateral streaks; terga V and VI dark brown; frons immaculate; tegula yellowish-white. In size and general facies closest to *M. parvula* Gess but differs from it in absence of frontal spots but in presence of pale markings on pronotum and terga and in yellowish-white rather than reddish-brown to black tegula.

Description.—Female: Black. The following are yellowish-white: narrow streak behind upper part of eye; humeral angle and postero-dorsal angle of pronotum; tegula (except for large median testaceous area); progressively reduced postero-lateral markings on terga I–IV; streaks of varying length on tibiae of all legs. The following are various shades of light reddish brown: mandible (except extreme base); underside of flagellomeres IV–IX and part of X; terga I–IV and sterna I–III (in part); apex of femur, tibia and tarsi of all legs (in part). The following are dark brown: terga V and VI and sterna III (in part) and IV–VI; femur (other than apex) of all legs.

Wings almost hyaline; veins light brown.

Length 6.0 mm; length of front wing 4.0



Figs. 2–6. Right tegula. 2. *Masarina mixta*, 3. *Masarina mixtoides*, 4. *Masarina namaqua*, 5. *Masarina parvula*, 6. *Masarina roberti*.

mm; length of extended tongue 3.0 mm; hamuli 7.

Head $1.25 \times$ as wide as long (measured across eyes and from vertex to bottom of emargination of clypeus respectively). Clypeus steeply raised from sides, disk $1.7 \times$ as broad as long (measured between lateral angles and from base to bottom of ventral emargination), flattened but not depressed medially; ventro-lateral corners rounded, lamellate and slightly upturned; ventral margin deeply emarginate, edentate; integument with moderately sized coarse punctures and longitudinal striae. Frons finely and closely punctured with punctures tending to run longitudinally. Mandibles long, narrow, evenly curved, tridentate. Eyes minutely setose.

Pronotum, most of mesoscutum, and pleura with moderately sized close punctures and scattered larger punctures; mesoscutum postero-medially, scutellum, and propodeum with somewhat finer punctures. Scutellum with disk bun-shaped, smoothly convex, anteriorly falling smoothly to meet mesoscutum, posteriorly falling smoothly but steeply and slightly overhanging metanotum; scutellar flange produced, overhanging and therefore covering metanotum laterally; hind margin of scutellum concave. Angles of propodeum tuberculate above. Terga similarly punctured to mesoscutum.

Tegula $1.9 \times$ as long as wide, laterally smoothly curved, posteriorly slightly narrowed and incurved (Fig. 6).

Front tarsomeres II–IV produced into inwardly directed lobes, that of II short, those of III and IV much longer, flattened, narrow and sub-parallel sided, that of IV reaching middle of V; middle tibia with one spur, hind tibia with shorter (outer) spur simple and longer (inner) spur bifid; claws of all legs minutely toothed.

Male.—Unknown.

Etymology.—The name, in the genitive singular, is formed from the name of the collector of the present specimen, Robert W. Gess, in recognition of the many years of his enthusiastic and perceptive assistance in the field.

Material examined.—Holotype: ♀, NAMIBIA: 12.8 km S of Rosh Pinah (28.03S 16.51E), 11.ix.1996 (F. W., S. K. and R. W. Gess) (on yellow flowers of *Osteospermum* sp., Asteraceae) [AMG].

Discussion.—*M. roberti* is the first species of *Masarina* recorded in association with Asteraceae.

KEY TO SPECIES OF MASARINA RICHARDS

The key to species of *Masarina* given by Gess (1997) is here presented in revised form to include the newly described species. As in the earlier key the as yet unknown female of *ceres* has been included using presumed characters for which reason it is given in []. On the other hand, the unknown males of *aptosimi* and *roberti* have been omitted.

FEMALES

1. Head, mandibles and antennae elongated; clypeus markedly convex transversely, raised, bulbous and nose-like *tylccodoni* Gess
- Head, mandibles and antennae not as above; clypeus either longitudinally depressed or, if convex, not raised, bulbous and nose-like 2
2. Frons with subtransverse carinae, each laterally downcurved before reaching middle of upper part of eye and ending in ocular sinus; middle tibia with two spurs 3
- Frons lacking carinae 4
3. Metasoma black; terga I–V with narrow, pale yellowish-white posterior bands; mesoscutum in greater part impunctate and very shiny; wings light brown *peliosomi* Gess
- Metasoma with terga I–III reddish-brown and IV–VI black, without yellowish-white markings; mesoscutum coarsely reticulate-punctate; wings very dark brown *aptosimi* Gess sp. nov.
4. Metasoma black with white or yellow markings *or* if red with yellow markings then small species (5.8 mm long) with clypeus shallowly depressed and, together with adjacent part of frons, longitudinally aciculate 5
- Metasoma partially or wholly red, with or without white or yellow markings (if small species then clypeus convex and not longitudinally aciculate) 7
5. Clypeus and adjacent part of frons markedly longitudinally aciculate; middle tibia with one spur 6
- [Clypeus and adjacent part of frons moderately coarsely punctured; middle tibia with two spurs] *ceres* Gess
6. Metasoma black with yellowish-white markings *strucki* Gess
- Metasoma red with yellowish white markings *hermanniae* Gess sp. nov.
7. Large (8.5–11.5 mm long) species with longitudinally depressed clypeus and with red pyriform tegulae 8
- Small to medium (5.8–8.2 mm long) species with convex clypeus and variously shaped white, red or black tegulae (if clypeus is slightly longitudinally depressed then tegula is black, broad and triangular) 9
8. Frons on each side above ocular sinus with large yellow spot; metasoma with yellow markings in addition to reddish ones; puncturation of head, thorax and metasoma coarse; propodeal angles tuberculate; scutellum with narrow, smooth, anterior furrow *familiaris* Richards
- Frons on each side above ocular sinus with small to minute reddish spot; metasoma with reddish markings only; puncturation of head, thorax and metasoma moderate; propodeal angles almost rounded; scutellum with wide, coarsely crenulate, anterior furrow *hyalinipennis* Richards
9. Terga I and II (and in some specimens III) predominantly red, contrasting with predominantly black terga III (or IV)–VI; frons immaculate 10
- Terga I–VI or I–V predominantly red; frons immaculate or maculate 11
10. Terga II–IV without any yellowish-white markings; tegula short and broad, as in Fig. 2 *mixta* Richards
- Terga II–IV with variously developed yellowish-white posterior bands; tegula elongate, as in Fig. 3 *mixtoides* Gess
11. Terga I–IV predominantly red with progressively reduced postero-lateral yellowish-white markings; frons immaculate; tegula posteriorly slightly narrowed and incurved, as in Fig. 6 *roberti* Gess sp. nov.

- Terga I-V predominantly red; frons on each side above ocular sinus with small yellowish-white spot 12
- 12. Tibia and tarsus of all legs reddish-brown; tegula markedly narrowed posteriorly; as in Fig. 4; clypeal disk $1.3-1.4 \times$ as wide as long *namaqua* Gess
- Tibia and tarsus of all legs dark brown with variously developed yellowish-white dorsal streaks; tegula evenly rounded posteriorly, as in Fig. 5; clypeal disk $1.6-1.7 \times$ as wide as long *parvula* Gess

MALES

1. Head, mandibles and antennae elongated; clypeus markedly convex transversely, raised, bulbous and nose-like *tylocodoni* Gess
- Head, mandibles and antennae not as above; clypeus either longitudinally depressed or, if convex, not raised, bulbous and nose-like 2
2. Metasoma black with white or yellow markings *or* if terga roughly transversely banded, black anteriorly, red medially, and yellowish-white posteriorly then small species (5.8 mm long) with clypeus shallowly depressed and, together with adjacent part of frons, longitudinally aciculate 3
- Metasoma partially or wholly red, with (*familiaris* only) or without white or yellow markings 6
3. Clypeus and adjacent part of frons convex; mesoscutum shiny, sparsely punctate; tegula black; middle tibia with two spurs *pellostomi* Gess
- Clypeus and adjacent part of frons longitudinally depressed; mesoscutum closely punctate; tegula yellow or yellowish-white; middle tibia with one or two spurs 4
4. Clypeus and adjacent part of frons markedly longitudinally aciculate; middle tibia with one spur 5
- Clypeus and adjacent part of frons moderately coarsely punctured; scape, mandible, labrum, clypeus, supraclypeal marking and ocular sinus yellow; middle tibia with two spurs *ceres* Gess
5. Metasoma black with yellowish-white markings; scape, mandible, labrum, clypeus and face black *strucki* Gess
- Metasoma with terga roughly transversely banded, black anteriorly, red medially, and yellowish-white posteriorly; scape, mandible, labrum, clypeus, supraclypeal marking and ocular sinus yellowish-white *hermanniae* Gess sp. nov.
6. Large (8.5–11.5 mm long) species with longitudinally depressed clypeus and with red, pyriform tegulae 7
- Small to medium (5.8–8.2 mm long) species with convex clypeus and variously shaped red or black tegulae (if clypeus is slightly longitudinally depressed then tegula is black, broad and triangular) 8
7. Frons on each side above ocular sinus with large yellow spot; clypeal disk and supraclypeal marking yellow; metasoma with yellow markings in addition to reddish ones; puncturation of head, thorax and metasoma coarse; propodeal angles tuberculate; scutellum with narrow, smooth, anterior furrow; sternum II unmodified; tergum VII emarginate apically *familiaris* Richards
- Frons on each side above ocular sinus immaculate; clypeal disk and supraclypeal marking pure white; metasoma with reddish markings only; puncturation of head, thorax and metasoma moderate; propodeal angles almost rounded; scutellum with coarsely crenulate anterior furrow; sternum II with a bituberculate prominence; tergum VII rounded apically *hyalinipennis* Richards

8. Terga I, II (and in some specimens III) predominantly red, contrasting with predominantly black terga III (or IV)–VII scape entirely black; mandible, labrum and clypeal disk either black or yellowish-white 9
 - Terga I–IV (at least) predominantly red, not contrasting with terga V–VII but rather gradually changing from red to reddish-brown to blackish; scape with yellow mark; mandible, labrum and clypeal disk always yellowish-white 10
9. Mandible, labrum, clypeal disk and broad supraclypeal marking yellowish-white; tegula short and broad, as in Fig. 2 *mixta* Richards
 - Mandible, labrum, clypeal disk and supraclypeus black; tegula elongate, as in Fig. 3 ...
..... *mixtoides* Gess
10. Frons with large, sub-quadrate, yellowish-white supraclypeal marking; entire hind tibia and basitarsus pale; tegula markedly narrowed posteriorly, as in Fig. 4; clypeal disk $1.2\text{--}1.3 \times$ as wide as long *uamaqua* Gess
 - Frons with at most narrow, transverse, yellowish-white supraclypeal marking; only proximal half of hind tibia pale; tegula evenly rounded posteriorly, as in Fig. 5; clypeal disk $1.4\text{--}1.5 \times$ as wide as long *parvula* Gess

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On the Mass Aggregations of *Polistes versicolor* (Olivier) (Hymenoptera: Vespidae) along the Northern Cordillera of Venezuela, South America

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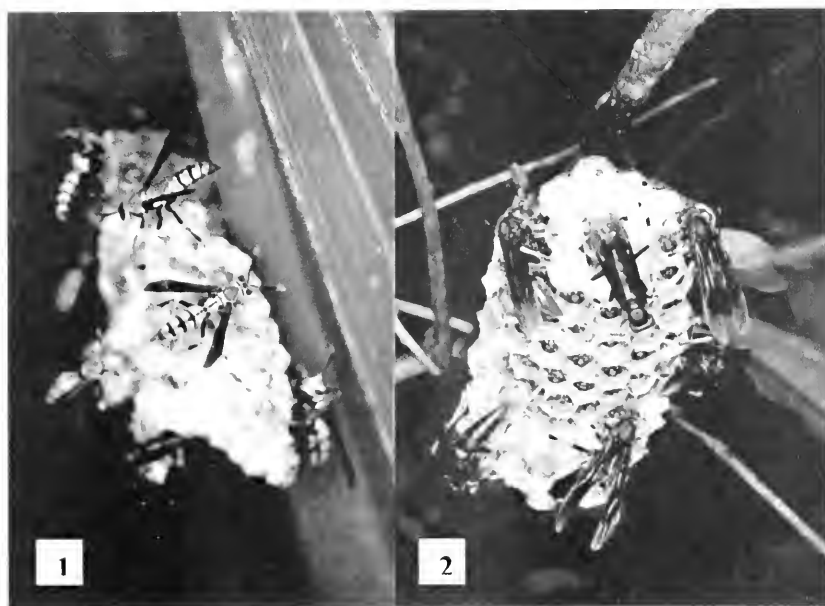
Abstract.—Aggregations of diapausing *Polistes versicolor* were observed and sampled at three sites in the Venezuelan Northern Cordillera (ca 2,400 m) during the dry season (November to April). During the wet season (May–October), *Polistes versicolor* occupies lowland areas where food supply appears to be abundant year round. Here it coexists with *P. canadensis* which does not move to the mountains during the dry season so there seems to be no basis for a seasonal diapause in *P. versicolor*. The phenomenon is compared with a conspecific population in Brazil that also has been reported to aggregate. Energy savings, escape from predators, and the presence of a pronounced dry season at lower elevations are some of the possible reasons for this behavior.

Resumen.—Agregaciones de *Polistes versicolor* en diapausa fueron observadas y colectadas durante la época seca (Noviembre a Abril), en tres lugares diferentes de la Cordillera de la Costa Venezolana (ca 2.400 m). Durante la época húmeda (Mayo–Octubre), *P. versicolor* ocupa áreas en Venezuela donde el suministro de alimentos es abundante todo el año. Aquí coexiste con *P. canadensis*, la cual no se mueve hasta las montañas durante la época seca, de manera que no pareciera existir una base para que tenga una diapausa estacional. El fenómeno es comparado con una población coespecífica estudiada en Brasil, la cual ha sido reportada en agregaciones. Ahorro energético, escape de depredadores o que la presencia de la época seca demanda la aparición de una diapausa, se mencionan como algunas de las razones para exhibir este comportamiento.

Some *Polistes* wasps from temperate regions form autumnal aggregations prior to a hibernation period (Hermann and Gerling 1974, Krispyn 1975, Rau 1930, 1931, Takamizawa 1981, West-Eberhard 1969). In contrast to the annual hibernation cycle of temperate *Polistes*, swarming followed by continued nest construction is generally associated with tropical members of the genus (Rau 1929, 1930, 1931, 1941). Despite the general nesting patterns for tropical species, mass aggregations of *Polistes* wasps have also been seen and reported from Brazil (Gobbi 1977, Gobbi and Zucchi 1985, González et al. 2002, Hughes 2002, Ihering 1904), Costa Rica

(Hunt et al. 1999, J. Pickering, pers. comm.), Cuba (J. Genaro, pers. comm.), Mexico (J. Strassmann, pers. comm., J. Hunt, pers. comm.), and Venezuela (Bequaert 1948, Manzanilla et al. 2000, Menke 1988, Steyermark 1945).

Polistes versicolor and *P. canadensis* (Figs 1–2) are two of the most common paper wasps below 1,000 m throughout the Neotropics from Costa Rica to Argentina (Carpenter 1996a, Ihering 1904, Mac Callan 1954, Richards 1978). In Venezuela, one of the areas where both species are sympatric is the slopes and lowlands along the Northern Cordillera or Coastal Mountainous System which lies between about 10 °



Figs 1–2. 1. *Polistes versicolor*; 2. *Polistes canadensis*. Both from Maracay, Aragua, Venezuela (450 m).

and 11° N, and 62 to 68° W, interrupted at the east by the Unare Depression. Its maximum heights are Naiguata peak (2,765 m) in the central area and Turimiquire peak (2,595 m) to the east.

During the dry season, from November to April, large aggregations of *P. versicolor* are regularly found along the highlands of some areas of the Northern Cordillera (P. Berry, F. Bisbal, J.B. Rodríguez, M.T. Badaraco, pers. comm.; L.J. Joly, J.L. García, F. Bisbal in Manzanilla et al. 2000) where it does not occur during the wet season. However, despite the common occurrence of this phenomenon, and the easy access to some sites it has been poorly documented. As a contribution to the overall knowledge of *Polistes* biology we review published material on tropical *Polistes* aggregations and report information from field collected mass-aggregated specimens of *P. versicolor* from Venezuela.

MATERIALS AND METHODS

Study sites.—Sites 1 and 2 were located at opposite ends of Colonia Tovar town (Northern Cordillera; 50 km west of Ca-

racas; Approximate Annual Mean: Temp. 15.8° C; 85 % RH) (Site 1: West of Colonia Tovar; Sector La Lagunita, Via Colonia Tovar—La Victoria, Aragua, Aprox. 2,400 m; Site 2: East of Colonia Tovar; Sector Geremba, Topo Botiquín, Miranda, 2 km from the Road Colonia Tovar—El Jarillo, 2,345 m). The life zone of sites 1 and 2 is that of a cloud forest characterized by a wet evergreen forest, with many hours of mist, mostly from mid afternoon to mid morning, with a temperate climate (Fernández-Badillo 1997, 2000).

Site 3 is located at Topo Galindo, Miranda, 2,550 m (Approximate Annual Mean: Temp. 10° C; 86 % RH). This site can be characterized as a subpáramo zone with shrubby vegetation, with almost constant mist (Fernández-Badillo 2000, Ortiz and Fernández-Badillo 2004).

Collection of specimens.—Wasps were collected on January 1st, 2004 from man-made structures, but they were also observed on vegetation at sites 1 and 2 (Figs 3–7), while at site 3 they were collected on February 4th, 2004 from natural crevices. A total of 128 wasps were collected from



Figs 3–8. Mass aggregation of *Polistes versicolor*, 3. inside a shack; 4. behind door; 5. cement wall crevice; 6. corner of rolling door; 7. rock crevice; 8. inside branches of *Cupressus lusitanica*. All photographs were taken with flash, since the wasps were in dark places. Arrows in figures 7 and 8 signal the wasps. Photographs 3–5, 8 from Sector Geremba, Topo Botiquín, Miranda, Venezuela; 6 from Sector La Lagunita, Via Colonia Tovar-La Victoria, Aragua, Venezuela; 7 from Topo Galindo, Miranda.

the three sites (38 from Site 1; 41 from Site 2; 49 from site 3). Ten wasps from each site were dissected to determine sex and condition of the reproductive system, and also if food was present in the midgut. Extent of wing tip wear of every wasp was also recorded.

Voucher specimens have been deposited at the Entomological Collection of the Museum of Natural History of the University of Georgia, Georgia, USA, as well as the Museum of Instituto de Zoología Agrícola of the Universidad Central de Venezuela, Maracay, Venezuela.

RESULTS

Aggregations of *P. versicolor* wasps were observed at three sites located in the

northern Cordillera of Venezuela at two neighbor states (Aragua and Miranda). They were located inside man-made structures (holes and crevices in walls—Figs 3–6), and also in natural crevices and inside the branches and leaves of some plants (Figs 7–8). Most wasps were clustered but at sites 1 and 2 some were observed flying on the vegetation, especially on flowers, and also around the aggregation groups. Some wasps in the aggregations were also clearly engaged in trophallaxis. No movements out of the hibernating groups were noticed in Site 3, probably due to rain and the low temperature during the day of collection.

All wasps collected at the three sites were females, and sub-samples showed

that most had undeveloped ovaries [Stage A (Gobbi 1977)]. A few of the collected wasps had large ovaries but no eggs (with apparent egg reabsorption signals) [Stage K (Gobbi 1977)]. No solid remains were found inside the guts of the dissected wasps. A minority of the collected wasps showed wing tip wear (15, 18, and 16 % from sites 1 to 3 respectively), a clear indication that at least some wasps were from the season previous to the one that just ended.

Interviews of some peasants from Colonia Tovar revealed that massive wasp aggregations occur annually from November to April, and treating the wasps with pesticides has been a common practice. According to all interviewed persons, the numbers of these aggregations have decreased over the years.

DISCUSSION

Mass aggregations of adult *Polistes* wasps were thought to occur mostly in temperate zones where the phenomenon is clearly related to hibernation (Hermann and Gerling 1974, Kryspin and Hermann 1977, Matsuura 1980, Takamizawa 1981). However, some *Polistes* species from different species groups [1, 2, 3 & 5 (Richards, 1973)] but of the same subgenus (Richards 1978, Carpenter 1996b) are known to gather in mass aggregations in tropical regions (*P. versicolor* (Gobbi 1977, Manzanilla et al. 2000); *P. instabilis* in Costa Rica, *P. cf. canadensis* in Mexico, *P. cubensis* in Cuba—J. Pickering, J. Strassmann, J. Genaro, respectively, pers. comm., Hunt et al. 1999) where there would seem to be no apparent seasonal demand for diapause.

Polistes versicolor has been reported in such abundance in some areas than it has become a major threat to some vertebrates (Grant and Grant 1997, Heraty and Abedrabbo 1992).

In Venezuela, this wasp species is commonly found north of the Orinoco River, mainly in the lowlands along the Andes

and the Northern Cordillera (Bequaert 1948, McCallan 1954). Manzanilla et al. (2000) also observed high densities of these wasps in the easternmost section of the Turimiquire massif, in Northern Venezuela, and they attributed the phenomenon to seasonal migration, associated with the dry season.

The areas of occurrence of *P. versicolor* are agricultural lands that appear to provide these and other wasps, with enough food supply the whole year. While the sympatric *P. canadensis* initiate new colonies and enlarge older ones throughout the year, *P. versicolor* wasps stop making nests and start moving in large groups to higher elevations of the Northern Cordillera by November. Flying in such large masses is not uncommon and seems to be a regular behavior of this species (Heraty and Abedrabbo 1992). Once the high altitudes (> 2,000 m) are reached, these wasps hide along crevices in rock walls, under rocks or man-made structures (Figures 3–7) where they spend the colder months until April when they return to warmer lands. While in these aggregations, they also hide or remain still on tree-trunks, branches, inside bushes, and other small plants (Fig 8) (Manzanilla et al. 2000, Steyermark 1945). It looks like the first known report of these mass aggregations in Venezuela was the one made by the famous botanist Julian Steyermark who observed "... billions of semi-dormant hibernating wasps covering the trees on the summit of Cerro Peonía or Pajaritos", a mountain located at the Turimiquire, in Anzoátegui State (Menke 1988, Steyermark 1945). Manzanilla et al. (2000) reported high densities from Cerro La Laguna also, which is located in the same mountainous region of Steyermark's observations. A similar situation was reported by Gobbi (1977) in Sao Paulo, Brazil, where *P. versicolor* have been found to hibernate in masses during the dry season, in geographic and weather conditions

similar to those we described for Venezuela.

From wasps collected at three different sites of the Northern Cordillera of Venezuela we found that they were only females, with large amounts of fat body, and subsamples showed that most had undeveloped ovaries, as expected for hibernating wasps (Hunt et al. 1999, Spradbery 1973). The relatively low incidence of wing wear among the aggregating wasps indicates that most are young. These characteristics were also found in hibernating aggregates of *P. versicolor* wasps found in Ribeirao Preto, Brazil (Gobbi 1977), but also noted in *P. instabilis* aggregations from Costa Rica (Hunt et al. 1999).

Once aggregations are in place, some individuals make short flights, probably to gather some "maintenance" food during periods of warmer temperatures, usually around mid-day. This behavior was also observed by Manzanilla et al. (2000). Gobbi (1977) and Gobbi and Zucchi (1985) also found that even while hibernating, some individuals of *P. versicolor* had solid food remains in their midgut. Additionally, these authors reported trophallaxis to be common among the individuals composing the aggregates. In our sample of wasps from each site no solid remains were found inside the midgut. Manzanilla et al. (2000) mentions also that residents of the Turimiquire area confirmed the occurrence of the aggregating phenomenon for "at least ten consecutive years". Based on Steyermark's (1945) remarks, the presence of aggregating wasps in this region is even older. According to residents of Colonia Tovar, the first wasps appear in these mountains around November, or about the end of the wet season. The numbers increase as the dry season starts. They fly in large groups and invade natural and artificial crevices, and any place where they can "hide". A common comment among the people in the area was that they have known the wasps "forever", and that the wasps were more numerous many years

ago, but since these insects "are annoying for agricultural and other activities", residents have normally sprayed them with pesticides. Daniel H. Janzen has noticed that the cloud level has moved to higher elevations in Costa Rica due to global warming (J.H. Hunt pers. comm.), this could be also another possible explanation why these wasps are less abundant than before in the surrounding areas of Colonia Tovar. Even though the wasps are not aggressive in these aggregations, they can sting if bothered. The wasps seem to "disappear" from the area after April.

The northernmost range of *P. versicolor* is Costa Rica and Panama where the species seems to swarm throughout the year but does not mass-aggregate (J. Pickering, pers. comm.). In Trinidad, where the mountains are lower than 1,000 m, neither these wasps, nor others in the genus appear to mass-aggregate at any season (C.K. Starr, pers. comm.).

In the tropics, *Polistes* species are basically lowland creatures; besides, *P. versicolor* occupies agricultural areas in Venezuela and in Brazil where food supply should be expected to be abundant year around, which would seem to make a need for a seasonal diapause unnecessary. However, the phenomenon is clear, common and happens every year, in both Brazil and Venezuela. *Polistes canadensis* and *P. versicolor* have broadly overlapping ranges in northern Venezuela, but while *P. canadensis* nests year-round, *P. versicolor* disappears during the dry season. Three of the many plausible reasons for *P. versicolor*'s aggregating behavior could be either that they go to a colder place for energetic savings, and metabolic costs would be minimal, and/or to escape from predators, who might find inactive wasps exceptionally vulnerable in the lowlands, or, as suggested by Hunt et al. (1999), the presence of a severe dry season is indeed a clear seasonal demand for diapause. Furthermore, even though *P. canadensis* remain active through the dry season in the

lowlands, in Costa Rica it has been observed that they sharply diminish productivity that increases only with the onset of the rainy season (J. Hunt, pers. comm.). Something similar could actually be happening in the Venezuelan lowlands during the dry season. Further and more detailed studies of this phenomenon will be needed to provide more insights into this particular behavior.

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A Review of North American Species of *Microdontomerus* Crawford (Torymidae: Hymenoptera)

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Abstract.—Four species of *Microdontomerus* Crawford have been recognized in the New World: *anthidii* (Ashmead), *anthonomi* (Crawford), *bicoloripes* (Crawford), and *fumipennis* Crawford. In this paper the genus is revised and the following new species are described: *apiannus*, *braconivorus*, *buprestae*, *ciscada*, *darwini*, *eboreus*, *enigma*, *gordli*, *hemileuca*, *mysticus*, *parkeri*, *rictus*, *secus*, *westcotti*, and *zoyphius*, making a total of 19 described New World species. Keys and illustrations are given to distinguish all species, and host and distribution data are summarized. The new species include parasitoids of range caterpillar eggs (possibly as hyperparasitoids); geometrid larvae; tachinid and braconid parasitoids of Lepidoptera; several burprestid crown borers; a cerambycid stem borer; root and stem weevils; and several solitary bees.

The genus *Microdontomerus* Crawford is known from nine species of which four are North American: *anthidii* (Ashmead), *anthonomi* (Crawford), *bicoloripes* (Crawford), *fumipennis* Crawford; four are Palearctic: *albipes* (Giraud), *annulata* (Spinola), *gallicolus* Zerova and Seryogina, *ovivorus* (Steffan); and one is Afrotropical: *senegalensis* (Risbec) (Grissell 1995, Zerova and Seryogina 1999, Noyes 2001). No species are yet known from the Australian or Oriental Regions, or from Central or South America. Because no keys or reviews have been published for the relatively few North American species of *Microdontomerus*, the purpose of this paper is to document the occurrence of 15 previously undescribed species for the area and to provide a key and illustrations to identify them. This paper essentially covers all known information for New World species of *Microdontomerus*, most of which appear to be primarily western North American.

Most species of *Microdontomerus* appear to have a narrow host range, but the over-

all array of insects attacked by members of the genus is conversely broad. For example, several species are parasitoids of various life stages of Lepidoptera; several attack larvae of bees and one attacks cynipids; one is an egg parasitoid of buprestids; and one has been reared from mantid egg cases. Several species have broad host ranges, and are hyperparasitoids through either a lepidopterous or coleopterous host. In the former case, the wasp also attacks ichneumonid parasitoids (Peigler 1985), and in the latter the wasp attacks tephritids that live in the same microhabitat (Turner et al. 1990). Hosts for new species described in this paper include range caterpillar eggs (possibly as a hyperparasitoid); geometrid larvae; tachinid and braconid parasitoids of Lepidoptera; several burprestid crown borers; a cerambycid stem borer; root and stem weevils; and several solitary bees. Apart from host data, little biological information is available for New World species, and what little is available is summarized under individual species below.

Species of *Microdontomerus* are rarely captured by sweeping or in traps (e.g., Malaise or yellow pan) and seem to be taken most often as rearings in association with a particular host insect under study. Some species appear to be quite common (e.g., those associated with bee rearings), but still are poorly represented in collections. Due to their relatively small size (2–4 mm), cryptic hosts, and difficulty of collection, it is likely that many additional species of *Microdontomerus* remain to be discovered.

METHODS

Recognition of species of *Microdontomerus* relies in large part on variations in several aspects of wing setation. The two extremes in setation are shown in Figs. 5 and 6. The latter figure shows an “open” basal cell, which occurs when the setation of the cubital vein does not extend to the base of the wing (i.e., it stops at the junction with the basal vein). When the setation does extend to the base it is considered a “closed” basal cell (Fig. 5). In some species there is a distinct admarginal area (posterior to the marginal vein, Fig. 6) that is nearly bare, having only a few random setae. In a few species this area (Fig. 5) is not distinct because it is covered with setae. Another important wing setation character involves whether the costal cell has setae on the apical margin of the dorsal surface (Figs. 5, 8) or not (Figs. 6, 7). So far no distinct differences have been found on the ventral surface. Various combinations of setal states exist involving the basal vein and setae within the basal cell, but these are rarely present/absent states and tend to vary between species by degree. In using setation characters it is necessary to have well preserved, clean specimens or at least a series of specimens because the setae are sometimes difficult to see or break off. They are best examined using light reflected from beneath the wing.

In the descriptions and key I use the torulus position in a general sense of wheth-

er it is below or above the ventral margin of the eyes. Because it is sometimes relatively difficult to judge the position by simple examination, I used an eyepiece cross-hair/measuring graticule as an aid. With the head in its most horizontal plane, one of the cross-hair lines was aligned horizontally across the venter of the eyes and the position of the torulus was determined relative to this line. For example, Figs. 26 and 27 show the dorsal margin of the toruli beneath the ventral eye margin, whereas Figs. 28 and 31–34 show the ventral margin of the toruli to varying degrees at (Figs. 34) or distinctly above (Fig. 31) the ventral eye margin. In some cases the toruli are intermediate just about at a midpoint above and below the margin (Figs. 29, 30).

Of some diagnostic use is whether or not the scape reaches the venter of the midocellus. In some cases the scape is appressed against the face, and it is obvious how much distance, if any, remains between its apex and ocellus. When this is not the case, it is possible to measure the length of the scape and compare it to the measured distance from the dorsum of a torulus to the venter of the median ocellus. Generally the distance can be expressed as a factor of whether or not the scape reaches or nearly reaches the ocellus (e.g., Figs. 29, 34) or is separated from it by a distinct gap (e.g., Figs. 26–28).

Host-plant names were checked using GRIN (2004) and host insects using Poole and Gentili (1996, and website: <http://www.nearctica.com/nomina/wasps/hymenop.htm>). Bee nomenclature follows Michener (2000). Because of the complexity of handling insect and plant host names, authors, and order and family information, I treat these data as follows: Author names for all insect hosts are given in the Host-Parasitoid list at the end of the paper, not the first time they appear in the text. Author names for plants are given in the species “Host” section rather than the “Material examined” section where they

are first mentioned as part of a collection label. Since plants are not the primary host, they are not listed in the Host-Parasitoid list. Family names for both insects and plants are included in the "Host" section as an aid to the reader in determining general host preferences.

Abbreviations used in the descriptions are: MV = marginal vein; PV = postmarginal vein; SMV = subcostal vein; SV = stigmal vein. Acronyms used for museums from which material was borrowed and curators who loaned the material (in parentheses) are as follows: CNC = Canadian National Collection, Ottawa, Ontario (G. A. P. Gibson); UCD = University of California, R. M. Bohart Museum, Davis, California (S. Heydon); UCR = University of California, Riverside, California (S. Frommer, S. V. Triapitsyn); USU = Utah State University (F. D. Parker, W. Hanson); USNM = National Museum of Natural History, Washington, DC.

Microdontomerus Crawford

Microdontomerus Crawford 1907b:179. Type-species: *Torymus anthonomi* Crawford, by original designation.

Antistrophoplex Crawford 1914:125. Type-species: *Antistrophoplex bicoloripes* Crawford, by original designation. [Synonymized by Grissell in Boucek 1982:189.]

Paraholaspis Masi 1921a:168–169. Type-species: *Paraholaspis cothurnata* Masi, by monotypy [= *annulata* Spinola]. [Synonymized with *Antistrophoplex* by Boucek 1976:347.]

Plastotorymus Masi 1921b:235–236. [Unnecessary n. name for *Paraholaspis* Masi 1921a, believed preoccupied by *Parholaspis* Berlese 1918:174 (Arachnida): Steffan 1962:30.]

Plastotrymus: Grissell 1995:202. Misspelling.

In my 1995 review of the family Tory-

midæ (Grissell 1995) I found it difficult to distinguish species of *Microdontomerus* from *Idiomacromerus* Crawford. At the time I could provisionally recognize the two genera based on a single character, namely the presence of a single anellus in the former instead of two (or more) found in the latter. This separation appeared to be operational as much as phylogenetic (especially in the definition of what an anellus is as discussed in Grissell 1995). While it is true that all species of *Idiomacromerus* have two anelli, it now appears that some specimens of *Microdontomerus* have two as well, even in the same species. For example, in a series of reared specimens of *M. bicoloripes*, which range in size from 2 to 3 mm, larger specimens have the first funicle segment quadrate to longer than wide and with placoid sensilla, but smaller specimens have the first funicle much wider than long and without sensilla. Intermediates occur in which the segment is reduced but has one sensillum. This reduction is uncommon but does occur.

It is possible that a more reliable character to separate these genera is that *Microdontomerus* does not have an occipital carina, whereas *Idiomacromerus* has either a well-defined carina or at least a fold, line, or change in sculpturing that can be seen at some angle of view. In some cases the latter condition is somewhat subjective, as is the recognition of anelli, so that recognition of genera is, in rare cases, nebulous. I suspect that as more species are recognized the overlap will completely obscure generic limits, but for now it seems better to recognize the genera until a thorough study of world species can be made.

KEY TO FEMALES OF NORTH AMERICAN MICRODONTOMERUS

1. Clava (Fig. 53) appearing 4-segmented, with ventral area of micropilosity (except proximal half of first clavomere); toruli (Fig. 29) midway above and below venter of eye; ovipositor 0.7× length of metatibia; admarginal area of forewing shaded *secus* Grissell, n. sp.

– Clava (Figs. 46, 55) appearing 3-segmented, without ventral area of micropilosity; other characters variable but not found in combination	2
2. Ovipositor sheaths much longer than entire body, about 6× metatibia (greatly curved over body and difficult to measure); clypeus broadly rounded, projecting beyond lateral corners of mouth (Fig. 34); antenna with most flagellomeres longer than wide and clava apically narrowly pointed (Fig. 47)	<i>darwini</i> Grissell, n. sp.
– Ovipositor sheaths at most as long as body, less than 2.5× metatibia (essentially pointing straight back and easily measured); clypeus at most narrowly rounded (Figs. 27, 31) and variable with respect to lateral corners of mouth; flagellomeres mostly wider than long and clava rounded (Figs. 48, 54) or at most broadly acute (Figs. 46, 50)	3
3. Scutellum dorsally flattened (Fig. 19, 21), either completely polished and shiny or less sculptured (aciculate) in contrast to anterior of scutum, never reticulately sculptured; venter of torulus half-way (Fig. 30) to nearly completely below ventral eye margin (Fig. 27); pedicel about 2× as long as broad apically (Fig. 46, 48); ocellocular distance greater than longest lateral ocellus diameter (Fig. 40)	4
– Scutellum dorsally arched (Figs. 16–18, 20), similar sculpture to scutum and neither polished nor shiny (if somewhat flattened sculpture reticulate); venter of torulus above ventral eye margin (Figs. 28, 31–33); pedicel 1.5× or less as long as broad (Fig. 50, 54, 55); ocellocular distance variable, but usually (i.e., common species) equal to or less than longest lateral ocellus diameter (Fig. 39)	9
4. Propodeum with denticle above posterolateral corner (Fig. 25); MT2-6 medially deeply incised (Fig. 41)	<i>buprestae</i> Grissell, n. sp.
– Propodeum without denticle above posterolateral corner (Fig. 24); MT2-6 medially at most slightly emarginate (Fig. 42)	5
5. Face broad (Fig. 26): toruli about 2 diameters apart, eye height about 1.5× malar distance, distance between eyes about 1.5× eye height; clypeus recessed relative to corners of oral fossa (Fig. 26); forewing admarginal area with reduced setation not reaching marginal vein (as in Fig. 8)	<i>ricтус</i> Grissell, n. sp.
– Face narrow (Fig. 30): toruli about 1 diameter apart, eye height 1.7–2.0× malar distance, distance between eyes less than 1.2× eye height; clypeus even with or projecting beyond lateral corners of oral fossa (Fig. 30); forewing admarginal area evenly setose nearly to marginal vein (Fig. 12)	6
6. Costal cell above with setal row along anterior margin (Fig. 12); propodeum with distinct, raised median carina, subtended laterally by nearly polished depressions bordered by irregular carinae (Fig. 24); longest lateral ocellus diameter less than 1.5× ocellocular distance	7
– Costal cell above without setal row along anterior margin (as in Fig. 6); propodeum with weak (as in Fig. 22) to distinct median carina not subtended by depressions or outlined by carinae; longest lateral ocellus diameter 1.5 to 2× ocellocular distance	8
7. Malar distance about 1.5× intermalar distance (Fig. 30); anellus transverse (Fig. 52) scutellum shiny but not polished, nearly evenly covered with aciculate sculpture	<i>ciscida</i> Grissell, n. sp.
– Malar distance about 2.0× intermalar distance (Fig. 35); anellus distinctly elongate (Fig. 48) scutellum shiny, essentially polished	<i>mysticus</i> Grissell, n. sp.
8. Propodeum medially faintly sculptured (aciculate), about as shiny as scutellum; with weak median carina barely raised above surface (as in Fig. 22); ocellocular distance about 2× longest lateral ocellus diameter; ovipositor nearly 1.5× metatibial length	<i>westcotti</i> Grissell, n. sp.
– Propodeum medially more heavily sculptured (reticulate) than scutellum; with strong median carina raised above surface (as in Fig. 24); ocellocular distance about 1.5×	

- longest lateral ocellus diameter; ovipositor about $1\times$ metatibial length *zoophins* Grissell, n. sp.
9. Forewing setation (Figs. 6, 7) reduced: basal cell open behind, i.e., cubital vein basally at most with few isolated setae; basal vein at most with isolated setae; basal cell without distinct setal row paralleling submarginal vein 10
- Forewing setation (Figs. 5, 11) not reduced (except in admarginal area of some species): basal cell closed behind, i.e., cubital vein essentially completely setose to base of wing; basal vein with distinct setal row and basal cell with setal row paralleling nearly entire submarginal vein 11
10. Postmarginal vein (Fig. 7) about $0.75\times$ as long as marginal vein; forewing with admarginal area (Fig. 7) not well defined posteriorly by setal line, with admarginal setae nearly as uniform as central area of wing *enigma* Grissell, n. sp.
- Postmarginal vein (Fig. 6) about $0.5\times$ as long as marginal vein; forewing with admarginal area (Fig. 6) well-defined posteriorly by setal line, with few sparse setae not as uniform as central area of wing *parkeri* Grissell, n. sp.
11. Costal cell without anterior setal row on upper margin (Figs. 9, 10, 11, 14) 12
- Costal cell with anterior setal row on upper margin (Figs. 8, 13, 15) 15
12. Admarginal area of forewing with dense setae reaching almost to marginal vein (Fig. 11, 14); axillular carina flattened and at least somewhat widened (Figs. 17, 18); intermalar distance $1.5\times$ or less than malar distance 13
- Admarginal area of forewing relatively sparsely setose with setae not reaching marginal vein (Figs. 9, 10); axillular carina narrow (Fig. 16); intermalar distance greater than $1.5\times$ malar distance 14
13. Posterolateral corners of propodeum angulate (Fig. 22); axillular carina obviously widened and triangularly expanded dorsally (Fig. 18); flagellum and femora black, scape and tibiae orange *gordhi* Grissell, n. sp.
- Posterolateral corners of propodeum rounded; axillular carina somewhat widened, but not expanded dorsally (Fig. 17); flagellum, scape, and legs concolorous white *eborens* Grissell, n. sp.
14. Ocellocular distance (Fig. 38) larger ($1.5\times$) than lateral ocellus diameter; pedicel about $1.5\times$ as long as wide at apex; ovipositor about $2.5\times$ as long as metatibia *bicoloripes* (Crawford)
- Ocellocular distance subequal to lateral ocellus diameter; pedicel (Fig. 50) about as long as wide at apex; ovipositor about $1.5\times$ as long as metatibia .. *hemilencae* Grissell, n. sp.
15. Eye height nearly $3\times$ malar distance (Fig. 31); distance between eyes less than eye height (Fig. 31) 16
- Eye height $2.5\times$ or less malar distance (as in Fig. 36); distance between eyes equal to or greater than eye height (as in Fig. 36) 17
16. Admarginal area of forewing more sparsely setose than central disk of wing, with setae unevenly spaced and bare areas near marginal vein (Fig. 8); ocellocular distance about $0.5\text{--}0.8\times$ lateral ocellus diameter *anthidii* (Ashmead)
- Admarginal area of forewing with dense, evenly spaced setae (similar to central disk of wing) reaching almost to marginal vein (Fig. 5); ocellocular distance about equal to lateral ocellus diameter *anthonomi* (Crawford)
17. Admarginal area of forewing with dense setae reaching almost to marginal vein (as in Fig. 5); admarginal and median area of wing with brown infumation; distance between eyes greater than eye height; ovipositor $1.5\times$ metatibia *fumipennis* Crawford
- Admarginal area of forewing relatively sparsely setose with setae not reaching marginal

- vein (Figs. 13, 15); wing hyaline; distance between eyes subequal to eye height; ovipositor less than $1\times$ or more than $2\times$ metatibia 18
18. Ovipositor obviously much shorter than metasoma, $0.5\times$ metatibia; scape black; wing veins white *braconivorus* Grissell, n. sp.
- Ovipositor obviously much longer than metasoma, as long as body, $2.5\times$ metatibia; scape mostly yellow; wing veins brown *apiannus* Grissell, n. sp.

***Microdontomerus anthidii* (Ashmead)**

Figs. 8, 16, 31, 54

Torymus anthidii Ashmead in Davidson 1896:26.

Lectotype ♀, designated by Grissell (1995: 203), Los Angeles County, California, USA (USNM, examined); 11♀, 1♂ (an additional 4 specimens too badly damaged to determine sex) paralectotypes same data as lectotype.

Microdontomerus anthidii (Ashmead): Huber 1927: 108 (generic transfer).

Lectotype female.—Body length excluding ovipositor 2.1 mm, ovipositor 0.7 mm. Body black with metallic green reflections except as follows: straw-yellow are: scape, flagellum (shaded to black), all tibiae; whitish are: all tarsi, wing veins.

Head: Distance between eyes shorter than eye height; clypeus (Fig. 31) projecting slightly beyond lateral corners of oral fossa; ratio of ocellocular distance: postocellar distance: lateral ocellus diameter $1:5:2$; toruli about own diameter above lower margin of eyes; toruli about 1 diameter apart; intermalar distance about $2.5\times$ malar distance; eye height about $3.5\times$ malar distance; antenna (Fig. 54♀) with pedicel laterally about $1.5\times$ as long as broad apically, anellus distinctly transverse, funicle segments all wider than long, flagellum slightly wider distally than proximally (somewhat spindle-shaped), scape not reaching median ocellus and separated from it by about one ocellus diameter. **Mesosoma:** Scutellum convex, not in same plane as scutum; metanotum and propodeum not in same plane as apex of scutellum; posterior axillular carina reduced and narrow (Fig. 16); dorsellum more or less flat, with obscure wrinkled sculpture; propodeum es-

entially without pits along apical margin (inconspicuous perpendicular carinae are present), medially somewhat flattened and shiny, with delicate carina extending from dorsal margin about half way to nucha which is a narrow, arched polished carina, posterolateral corner of propodeum rounded, without distinct projecting denticle; spiracle greater than its own longest inner diameter from posterior margin of metanotum, median length of propodeum about $4\times$ longest inner spiracle diameter; forewing (Fig. 8) ratio PV: MV:SV:SMV as $15:23:7:45$, postmarginal vein about $0.7\times$ marginal vein, costal cell below with 1 to 2 complete anterior setal rows, apical $\frac{1}{2}$ setose below, upper surface with complete anterior setal row; basal setal line incomplete with gap towards anterior (below submarginal vein); cubital setal line complete (i.e., basal cell closed), with partial bare areas paralleling either side, dorsal area ending at about midpoint of marginal vein, ventral area ending at about apex of marginal vein; basal cell with 1 or 2 setae basally [no row in lectotype but present in paralectotypes]; admarginal area not defined by posterior setal line, with few wide spaced setae on bare area paralleling marginal vein; parastigmal area and basal area bare; stigmal area setose to apex of postmarginal vein. **Metasoma:** Terga entire at apico-median margin; ovipositor sheaths subequal in length to metasoma, $1.2\times$ as long as metatibia.

Male paralectotype.—Body length 1.3 mm. Color, sculpture, and other characters about as for female except: eye height nearly $4\times$ malar distance; scape ventrally

flat and polished; antenna (Fig. 54♂) with F1–2 anellus-like (i.e., without apparent multiporous plate sensilla); basal cell with 3 or 4 setae basally posterior to submarginal vein.

Variation.—The following discussion of variation is based on the paralectotype series (comprised of 7 points with 16 specimens, scarcely any of which are entire) and then compared to a long series of specimens from Riverside, California. In the type series, female body lengths (without ovipositor) range from 1.6 to 2.0 mm (there is only one male as described above). The median propodeal carina varies from absent to about half the propodeal length. The upper, anterior row of setae in the costal cell may be interrupted and thus be incomplete (apparently because the setae have broken off). The basal setal line is complete in most specimens, and the basal cell has a setal line that reaches half way or more to the basal vein. In measurable females ($n = 3$), the ovipositor is 1.1 to 1.2 \times as long as the metatibia.

In the Riverside specimens, female body lengths (without ovipositor) range from 1.6 to 2.3 mm, and males from 1.5 to 2.0 mm. The propodeal carina varies from about half the propodeal length (as in the lectotype) to a single complete carina, to several somewhat irregular carinae. The basal cell has a setal line reaching from half way to all the way to the basal vein. The ovipositor ranges from 1.0 to 1.2 \times as long as the metatibia.

In all specimens the ocellocular distance is less than the lateral ocellus diameter, varying from 0.5 to 0.75 \times the greatest ocellus diameter. The median propodeal carina appears to vary based on size, with smaller specimens having none and larger ones having several irregular carinae.

A series of 23 female specimens from Glamis, California (USU), differ from typical *M. anthidii* in having consistently longer ovipositor sheaths from 1.5 to 2.2 \times the metatibial length. These specimens were

reared from a vespid host (see Hosts, Discussion, below) and it is possible they represent a distinct species, but additional rearings of both morphotypes are needed to solve this problem.

Material examined.—I have seen the type material as detailed above and the following from California: 1♀, 1♂ Inyo Co.: 31 mi. ENE Big Pine, 25 May 1994, S. Heydon, off *Eucelia* (UCD); 36♀, 5♂ Riverside Co.: Riverside, 3 April 1938, Timberlake, ex nest *Dianthidium* (UCR); 2♀ Riverside, March 1971, A. R. Hardy, ex resin bee nest (UCR); 1♀ White Water, 27 March 1955, W. R. Mason (CNC); San Bernardino Co.: 2♀ Apple Valley, 20 May 1955, W. R. Mason (CNC); 1♀ Daggett, 22 May 1955, W. R. Mason (CNC); 1♀ Helendale, 27 May 1955, W. R. Mason (CNC); 2♀ Hesperia, 12 June 1952, Timberlake, ex nest *Dianthidium* (UCR); 23♀, 9♂ Imperial Co.: Glamis, coll. January 1964, F. Parker, ex *Leptochilus* nests in old beetle borings in *Ephedra* stems (F. Parker per. comm.) (USU, USNM).

Distribution.—Known so far only from southern California.

Hosts.—The type series was reared from *Dianthidium pudicum consimile* (as *Anthidium consimile*), and some other specimens were reared from the same host genus. The series reared from stems containing pupal cells of *Leptochilus* are only tentatively placed as *M. anthidii* (see Variation, above, and Discussion, below).

Discussion.—In 1995 I designated a lectotype for this species (Grissell 1995) without giving a reason for doing so. As a number of specimens were described by Ashmead (in Davidson 1896), but none was selected as holotype, I selected a single female as lectotype to insure nomenclatural stability.

Microdontomerus anthidii, *M. enigma*, and *M. parkeri* are all reared from bees, and for some time I had confused their identities. Generally *M. anthidii* is smaller (2.3 mm or less) with a shorter ovipositor (less than 1.2 \times metatibia), whereas *M. parkeri* is larg-

er (up to 3.0 mm) with a longer ovipositor (more than $2\times$ metatibia). *Microdontomerus enigma* is about the size of *M. anthidii*, but with the longer ovipositor of *M. parkeri*. *Microdontomerus anthidii* is fairly easily separated from the other two, however, based on discrete morphological differences in the forewing: *M. anthidii* has a complete setal row along the upper anterior margin of the costal cell (absent in the latter two species) and the basal cell is closed (open in the latter two species).

It appears that while all three species attack megachilid bees, *M. anthidii* is usually associated with species of the tribe Anthidini that create nests of resin and sand grains, whereas *M. parkeri* and *M. enigma* are associated with Osminiini and Megachilini that make stem nests. Interestingly, the questionable specimens of *M. anthidii* from Glamis, which appear to differ from typical *M. anthidii* only in ovipositor length, were reared from stems in which euminine vespid larvae coated their cocoons with sand grains incorporated into the cover of each cell by the adult female wasp (F. Parker, pers. comm.).

Microdontomerus anthonomi (Crawford)

Figs. 5, 20

Torymus anthonomi Crawford 1907a:133. Lectotype ♀, designated by Grissell (1995: 203), Waco, Texas, USA (USNM); 1♂ paralectotype same as lectotype, 2♀ paralectotypes, Hallettsville, Texas (USNM).

Microdontomerus anthonomi (Crawford): Crawford 1907b: 179 (type of new genus).

Holotype female.—Body length excluding ovipositor 3.0 mm, ovipositor 1.4 mm. Body black with metallic green reflections except as follows: orange are: scape, flagellum (shaded to black), apices of femora (metafemur most extensive at $\frac{1}{4}$), all tibiae; whitish are: all tarsi, wing veins. **Head:** Distance between eyes shorter than eye height; clypeus projecting slightly beyond lateral corners of oral fossa; ratio of ocellular distance: postocellar distance: lateral ocellus diameter 1:3:1; torulus

slightly less than own diameter above lower margin of eyes; toruli about own diameter apart; intermalar distance about $2\times$ malar distance; eye height about $3\times$ malar distance; antenna with pedicel laterally about $1.5\times$ as long as broad apically, anellus distinctly transverse, funicle segments all wider than long, flagellum slightly wider distally than proximally, scape not reaching median ocellus and separated from it by about one ocellus diameter. **Mesosoma:** Scutellum convex (Fig. 20), not in same plane as scutum; metanotum and propodeum not in same plane as apex of scutellum; posterior axillular carina reduced and narrow (Fig. 20); dorsellum more or less flat, with obscure wrinkled sculpture but no distinct carinae; propodeum with row of pits along apical margin, pits largest medially growing smaller laterally, medially with complete irregular carina more pronounced in dorsal than ventral half, nucha a narrow, lunate polished carina, posterolateral corner of propodeum rounded, without distinct projecting denticle; spiracle about $2\times$ own longest inner diameter from posterior margin of metanotum, median length of propodeum about $3\times$ longest inner spiracle diameter; forewing (Fig. 5) ratio PV:MV:SV:SMV as 15:24:8:48, postmarginal vein about $0.6\times$ marginal vein, costal cell below with 2 to 3 complete anterior setal rows, essentially covered except for lunate area medially, upper surface with setae along anterior margin in apical half (best seen on right wing); basal setal line complete; cubital setal line complete (i.e., basal cell closed), with bare areas paralleling either side, dorsal area ending at about midpoint of marginal vein, ventral area ending at about apex of marginal vein; basal cell with partial anterior setal row paralleling submarginal vein; admarginal area not defined by posterior setal line, evenly covered with setae but narrow bare area paralleling marginal vein, parastigmal area and basal area bare; stigmal area with narrow bare surface to

apex of postmarginal vein. **Metasoma:** MT2 slightly emarginate at apico-median margin, remaining terga entire; ovipositor sheaths subequal in length to metasoma, about $1.9\times$ as long as metatibia.

Male paralectotype.—Body length 2.0 mm. Color, sculpture, and other characters about as for female except: malar distance shorter, intermalar distance nearly $3\times$ malar and eye height nearly $4\times$ malar distance; stigmal area with several setae (i.e., not appearing bare).

Variation.—Based on all examined specimens, females vary in length from 2.0 to nearly 4.0 mm (excluding ovipositor); males from 1.0 to 2.5 mm. Color is the most variable aspect, even within the same population. Especially variable is the amount of orange on the femora. At one extreme, only the apex of the metafemur is orange, and at the other all femora are orange. In some populations the scape and pedicel may be entirely orange, entirely black, or some combination of both with the orange color beginning at the base of the scape and expanding upwards. In some specimens of both sexes, the stigmal area may have several setae and not appear bare as is typical for this species. In one population (Napa County, California, UCD) there is a slight brownish infumation near the stigma in six out of seven specimens.

Material examined.—Type material is detailed in the synonymy above. In addition I have seen 166♀ and 34♂ from the following countries and states (CNC, UCD, UCR, USNM, USU): Canada (British Columbia); Mexico (Durango, Sonora, Oaxaca); USA: Arizona, Arkansas, California, Colorado, Georgia, Idaho, Kansas, Maryland, Montana, Nebraska, New Jersey, North Carolina, South Carolina, Texas, Utah, Washington. Additional published state records not confirmed: Louisiana, Missouri, Oregon, Virginia (Peck 1963, Grissell 1979).

Distribution.—This species is transcontinental in the continental United States and

has been found in the north from British Columbia, Canada to Oaxaca, Mexico in the south.

Hosts.—In Crawford's paper (1907a) no rearing records were explicitly given listing *Anthonomus grandis* as a host, but the type material all bear labels reading "*Anthonomus grandis*" (Curculionidae) and the title of the paper was "New hymenopterous parasites of *Anthonomus grandis*, Boh." (see also discussion in Turner et al. 1990). Crawford (1907a) stated that one additional female was reared from *Brachytarsus* (now = *Trigonorhinus*) in heads of *Sideranthus rubiginosus* (Torr. & A. Gray) (now = *Haplopappus rubiginosus* Torr. & A. Gray according to W³TROPICOS 2004; I cannot confirm the host record based on extant specimens). Peck (1963) gave a list of papers relating to hosts of this species, but I have not been able to confirm all records by examination of voucher specimens. Hetz and Johnson (1988) added many new hosts, especially related to leguminous seedpods. Turner et al. (1990) summarized the known hosts and biology and added several new records.

The collective known insect host records include the following (all confirmed by this study): Anthribidae: *Trigonorhinus* sp.; Chrysomelidae (Bruchinae): *Acanthoscelides aurcolus*, *A. compressicornis*, *A. desmanthi*, *A. derifieldi*, *A. horni*, *A. mixtus*, *A. pulus*, *Bruchus brachialis*, *B. pisorum*, *Sennius morosus*, *Stator limbatus*, *S. pruininus*; Curculionidae: *Anthonomus grandis*; Coleophoridae: *Coleophora malivorella*, *C. parthenica*; Tortricidae: *Ancylys comptana*; and Braconidae: *Bracon mellitor*.

Plant host associations (i.e., without known insect host) confirmed by this study are (specimens in CNC, USNM): all Fabaceae: ex seeds *Acacia constricta* Benth.; ex seed pod *Astragalus asymmetricus* E. Sheld., ex seeds *A. douglasii* (Torr. and A. Gray) Jeps., ex seed pod *A. lentiginosus* Douglas ex Hooker, ex seed pod *A. prae-longus* E. Shield, ex seed pod *A. thurberi* A. Gray, ex seed pod *A. wootoni* E. Shield.; ex

seeds *Calliandra eriophylla* Benth.; ex seeds *Cassia covesii* A. Gray, ex seed pod *C. roemeriana* Scheele; ex seeds *Cercidium floridum* Benth. ex A. Gray; ex seeds *D. covillei* (Britton and Rose) Wiggins ex B. L. Turner, ex seed *Desmanthus illinoensis* (Michx.) MacMill. ex B. L. Bor. and Fernald, ex seed *D. velutinus* Scheele, ex seeds *D. virgatus* (L.) Willd.; ex seeds *Indigofera suffruticosa* Mill.; ex seeds *Mimosa biuncifera* Benth.; ex seed *M. microphylla* Dry.

In addition, *M. anthonomi* has been reared from insects introduced into the Nearctic as biological control agents of various weeds (Asteraceae except as noted), including the weevils *Rhinocyllus conicus* on thistle (*Carduus* spp.: Wilson and Andres 1986, Littlefield 1991), *Bangasterius orientalis* on yellow starthistle (*Centaurea solstitialis* (L.)), and *Microlarinus lareynii* on puncturevine (*Tribulus terrestris* L.: Zygophyllaceae), and also the tephritid *Urophora affinis* on yellow starthistle (Turner et al. 1990) and several other knapweeds (*Centaurea maculosa* Lamarck, *C. diffusa* Lamarck) (Goeden and Ricker (1970) [identified as *Microdontomerus* sp.], Lang and Richard 1999).

Biology.—Early work on the biology of this species was published by Pierce (1908a, 1908b, 1910) and Pierce et al. (1912, including figures of egg, pupa, and adult). These papers were summarized by Turner et al. (1990). The species is a solitary ectoparasitoid and also functions as a facultative hyperparasitoid. As a parasitoid of *Anthrenus grandis*, the wasp attacks weevil larvae in buds, seed capsules, and stems. Twenty-three percent of interactions with *Anthrenus* were as a secondary parasitoid through *Bracon mellitor*. Hansson et al. (2004) reported a species of *Microdontomerus* comprising 2.9% of the guild of parasitoids attacking *Acanthoscelides* in several species of *Phaseolus* in Mexico. This *Microdontomerus* is almost certainly *M. anthonomi* based on the host.

Although the majority of reported hosts appear to be beetles, especially those as-

sociated with seed pods or seed heads, *M. anthonomi* appears to be a host-species generalist, but a microenvironment specialist on hosts enclosed in flower or seed heads. It does not seem surprising that it has been reared from non-beetle hosts in seed heads (e.g., Lepidoptera) or that it attacks insects introduced from Europe for the biocontrol of weeds (e.g., Diptera, Coleoptera). In the latter instance, over a period of 20 years of sampling, parasitism has never risen over 2–3% (Lang and Richard 1999).

Discussion.—In 1995 I designated a lectotype for this species (Grissell 1995) without giving a reason for doing so. At that time the status of the type material was questionable. Crawford (1907a) listed the type locality as Waco, Texas, from which 1 female and 1 male were collected and both were marked "Type" in his handwriting. Two females from Hallettsville, Texas, were listed as "also" examined; these specimens were labeled "paratypes" in Crawford's hand. Crawford possibly meant the male and female "types" to be holotype and allotype, but this still left the question of which sex was the holotype. To insure stability of nomenclature I designated the female as lectotype for the species (Grissell 1995). Crawford (1907a) listed a female specimen from Mexia, Texas as part of the material he examined. This specimen has not been found. It is the only voucher for the rearing from *Trigonorrhinus*.

Microdontomerus anthonomi superficially resembles *M. parkeri*, but differs from that species distinctly in wing setation (cf. Figs. 5 and 6). It also resembles *M. anthidii*, from which it differs by characters outlined in the key.

Microdontomerus apiannus Grissell,
new species

Fig. 13

Holotype female.—Body length excluding ovipositor 3.0 mm, ovipositor 2.3 mm. Body black except: head dorsally with

slight metallic green tinge; yellow-orange are: scape, legs excluding coxae (fore and mesofemora slightly darkened); all tarsi whitish; wing veins brown. **Head:** Distance between eyes subequal to eye height; clypeus barely projecting beyond lateral corners of oral fossa; ratio of ocellular distance: postocellar distance: lateral ocellus diameter 6:13:6; venter of toruli nearly on line with lower margin of eyes; toruli about own diameter apart; intermalar distance about $1.7\times$ malar distance; eye height about $2.2\times$ malar distance; antenna with pedicel laterally about $1.5\times$ as long as broad apically, anellus nearly quadrate subequal in length to F1, funicle segments all wider than long, flagellum slightly wider distally than proximally but not noticeably spindle-shaped, scape almost reaching median ocellus.

Mesosoma: Scutellum convex, not in same plane as scutum; metanotum and propodeum not in same plane as apex of scutellum; posterior axillular carina reduced and narrow; dorsellum slightly convex, with dense reticulate sculpture similar to propodeum; propodeum medially with pits along apical margin, with dense reticulate sculpture about as on scutellum, with distinct median carina extending from dorsal margin to nucha which is a narrow, arched polished carina, median carina subtended by obscure depression on either side, posterolateral corner of propodeum rounded, without distinct projecting denticle; spiracle about its own longest inner diameter from posterior margin of metanotum, median length of propodeum about $3.5\times$ longest inner spiracle diameter; forewing (Fig. 13) ratio PV: MV:SV:SMV as 6:10:3:30, postmarginal vein about $0.6\times$ marginal vein, costal cell below with 2 to 3 anterior setal rows, upper surface with few setae along anterior margin [difficult to see in any specimen]; basal setal line complete; cubital setal line with several setae absent basally (broken off, but complete in paratypes; i.e., basal cell closed.), with partial bare areas par-

alleling either side, dorsal area ending at about midpoint of marginal vein, ventral area ending at about apex of marginal vein; basal cell with 3 or 4 setae [complete row present in paratypes]; admarginal area partially defined by irregular posterior setal line, with about 12 wide spaced setae on bare area; parastigmal area and basal area bare; stigmal area setose to apex of postmarginal vein. **Metasoma:** T2 slightly emarginate at apico-median margin, remaining terga entire; ovipositor sheaths subequal in length to body including head, $2.5\times$ as long as metatibia.

Male.—Body length 2.0 mm. Characters about as for female except: eye height $3\times$ malar distance; scape ventrally flat and polished.

Variation.—In the paratype series, females vary in length from 3.0 to 3.8 mm. The ovipositor varies from about 2 to $3\times$ as long as the metatibia. The extent of setation on the forewing is variable with the dorsal surface of the costal cell having a few setae along the anterior margin but these are very difficult to see. The setal row in the basal cell is partial to complete. A female from Nixon, Washoe County, Nevada, appears to be this species but is only 2 mm in length. The other characters are within the parameters of typical *M. apianus*, so I believe this small specimen belongs to this species, but I hesitate to include it (and a male from the same locality) in the type series without more material upon which to judge the extent of variation.

Type material.—Holotype ♀, Puente Hills, Los Angeles Co., California, February 26, 1926, Timberlake, found dead March 13, 1926, ex. *Megachile montivagus* [= *montivaga*] (UNSM); 12♀, 1♂ paratypes same data (UCR, USNM).

Other material examined.—Nevada: Washoe Co.: 1♀, 1♂ Nixon, F. D. Parker, reared from bee cell.

Etymology.—From the Latin "*apianus*", "of bees", in reference to the host.

Distribution.—Known from California.

Host.—Reared from *Megachile montivaga* (Megachilidae).

Discussion.—This species shares the following characters with *M. anthidii*: basal cell closed posteriorly (Fig. 13), costal cell above with setae along anterior margin (Fig. 13; more apparent in *anthidii*, Fig. 8), admarginal area of forewing sparsely setose, postmarginal vein about $0.7\times$ marginal vein, toruli just above lower eye margin (as in Fig. 31), and short scape (one or more ocellus diameters from median ocellus). *Microdontomerus apianus* differs in having the intermalar distance about $1.7\times$ the malar distance (about $2.5\times$ in *M. anthidii*), and in having the ovipositor sheaths subequal to the body length and $2.0\text{--}3.0\times$ as long as the metatibia (in *M. anthidii* ovipositor sheaths subequal to metasoma and usually less than $1.5\times$ as long as metatibia, but in one questionable population nearly $2.0\times$).

***Microdontomerus bicoloripes* (Crawford)**
Figs. 9, 36, 38

Antistrophoplex bicoloripes Crawford 1914:125. Lectotype ♀, designated by Grissell (1995: 204), Garden City, Kansas, USA (USNM); 5♀ paralectotypes same as lectotype.

Microdontomerus bicoloripes (Crawford): undesignated new combination by Grissell (1995: 204).

Lectotype female.—Body length excluding ovipositor 3.0 mm, ovipositor 2.2 mm. Body brown without metallic reflections; orange are: scape, pedicel, all legs including forecoxa; white are: wing veins, all tarsi. **Head**: Distance between eyes subequal to eye height; clypeus (Fig. 36) even with lateral corners of oral fossa; ratio of ocellular distance: postocellar distance: lateral ocellus diameter 11:23:8 (Fig. 38); torulus less than own diameter above lower margin of eyes; toruli about 1 diameter apart; intermalar distance about $1.8\times$ malar distance; eye height about $2.3\times$ malar distance; antenna with pedicel laterally about $1.7\times$ as long as broad apically, anellus distinctly transverse, funicle segments

all wider than long, flagellum slightly wider distally than proximally but appearing essentially parallel-sided, scape not reaching median ocellus and separated from it by about half an ocellus diameter. **Mesosoma**: Scutellum convex, not in same plane as scutum; metanotum and propodeum not in same plane as apex of scutellum; posterior axillular carina reduced and narrow; dorsellum more or less flat, with obscure wrinkled sculpture but no distinct carinae; propodeum laterally with obscure pits along anterior margin (perpendicular carinae present), medially flattened, with distinct carina extending from dorsal margin to nucha, posterolateral corner of propodeum rounded, without distinct projecting denticle; spiracle about $0.5\times$ own longest inner diameter from posterior margin of metanotum, median length of propodeum about $2\times$ longest inner spiracle diameter; forewing (Fig. 9) ratio of PM:MV:SV:SMV as 20:40:11:70, postmarginal vein about $0.5\times$ as long as marginal vein; costal cell below with 1 to 2 complete anterior setal rows, upper surface without setae; basal setal line with setae; cubital setal line with setae (i.e., basal cell closed), with partial bare areas paralleling either side, dorsal and ventral areas ending at about midpoint of marginal vein; basal cell with row of setae; admarginal area not defined by posterior line of setae, evenly covered with setae, parastigmal area and basal area bare; stigmal area bare to apex of postmarginal vein. **Metasoma**: MT2 slightly emarginate at apico-median margin; other terga entire; ovipositor sheaths slightly less in length than meso and metasoma, $2.5\times$ as long as metatibia.

Male.—Body length 1.6 to 2.3 mm. Color as in female, except femora with metallic greenish black varying from basal half to near apex; scape varying from orange to orange infused with black, especially dorsally.

Variation.—Paralectotype females vary in length from 2.3 to 3.0 mm. The few oth-

er specimens range from 2.0 to 3.0 mm. The ovipositor varies from about 2.0 to 2.5× as long as the metatibia. Paralectotype females colored as in lectotype. In non-type females the body color varies from as in the paralectotypes to dark metallic greenish black and the legs vary from orange (as in the lectotype) to having varying amounts of metallic greenish black on the femora from the base to the apex.

Material examined.—Type material is detailed in the synonymy above. In addition I have seen 12♀ and 8♂ as follows (all USNM): Arizona: Maricopa Co.: 3♀, 6♂ Cave Creek, 10 May 1923, L. H. Weld, ex galls *Aulax* [= *Antistrophus*] *chrysothamni*. Iowa: Woodbury Co.: 2♀ Sioux City, C. S. Ainslie, reared from *Lygodesmia* sp. Kansas: Finney Co.: 6♀, 2♂ Garden City, 24 September 1913, C. H. Popenoe, ex cynipid galls on *Lygodesmia juncea*; Ellis Co.: 1♀ Elis, ex *Antistrophus pisum* [= *lygodesmiaepisum*] on *Lygodesmia* sp.

Distribution.—Known from Arizona, Kansas, and Iowa.

Host.—This species is associated with several species of *Antistrophus* (Cynipidae) galls on *Lygodesmia* (Asteraceae). The type series was reared from *Antistrophus* galls [stated in paper, but not on specimens] in Kansas. It has been reared from *A. chrysothamni* (Arizona) and *A. lygodesmiaepisum* in Kansas. Brandhorst (1943, 1964) discussed *M. bicoloripes* reared from the latter gall on *Lygodesmia juncea* (Pursh.) D. Don in Kansas (1943) Iowa (1964).

Discussion.—In 1995 I designated a lectotype for this species (Grissell 1995) without giving a reason for doing so. Crawford (1914) described this species from 6 females without designating a specimen as holotype. To insure nomenclatural stability I selected a single female as lectotype.

Microdontomerus bicoloripes is difficult to distinguish from *M. parkeri*, and their differences are discussed at length under the latter species.

Microdontomerus braconivorus Grissell, new species

Figs. 1, 15

Holotype female.—Body length excluding ovipositor 2.3 mm, ovipositor 0.3 mm. Body black except as follows: yellow are: fore and mesotibiae (metatibia medially shaded to black); whitish are: tarsi, wing veins. **Head**: Distance between eyes subequal to eye height; clypeus on line with lateral corners of oral fossa; ratio of ocellular distance: postocellar distance: lateral ocellus diameter 1:2.7:1; torulus slightly more than own diameter above lower margin of eyes; toruli slightly greater than 1 diameter apart; internalar distance about 2.0× malar distance; eye height about 2.5× malar distance; antenna with pedicel laterally about as long as broad apically, anellus distinctly transverse, funicle segments all wider than long, flagellum slightly wider distally than proximally, clava not acuminate, scape not reaching median ocellus, separated from it by about one ocellus diameter. **Mesosoma**: Scutellum convex, not in same plane as scutum; metanotum and propodeum not in same plane as apex of scutellum; posterior axillular carina narrow, polished; dorsellum convex, reticulate with irregular carinae; anteromedian area of propodeum with several pits on either side of median carina, medially with complete carina reaching to nucha, nucha a narrow, lunate polished carina, posterolateral corner of propodeum rounded, without distinct projecting denticle; spiracle about 1× own longest inner diameter from posterior margin of metanotum, median length of propodeum about 4× longest inner spiracle diameter; forewing (Fig. 15) ratio PV:MV:SV:SMV as 15:28:9:50, postmarginal vein about 0.6× marginal vein, costal cell below with 2 to 3 complete anterior setal rows and essentially covered except for small lunate area medially, upper surface with setae along anterior edge in distal third; basal setal line



braconivorus 1



buprestae 2

Figs. 1–2. *Microdontomerus* spp.; female habitus.

complete; cubital setal line complete (i.e., basal cell closed), with bare areas paralleling either side, dorsal and ventral areas ending at about midpoint relative to marginal vein; basal cell with anterior setal row paralleling submarginal vein; admarginal area without posterior setal line, evenly covered with setae, parastigmal area and basal area bare; stigmal area with narrow bare surface to apex of postmarginal vein. **Metasoma:** Terga without emarginations at apico-median margin; ovipositor sheaths much shorter than metasoma, $0.5\times$ as long as metatibia.

Male.—Body length 1.7 mm (all specimens). Color, sculpture, and other characters about as for female except: pro and mesotibiae white, metatibia apically white; F1-2 anelliform, club apically pointed; eye height about $3\times$ malar distance.

Variation.—Females vary in length from 2.0 (ovipositor 0.3) to 2.5 (ovipositor 0.3) mm. There is no observable variation in the specimens available.

Type material.—Holotype ♀, New Mexico, Hildago Co., 14.7 mi. S Animas, coll. 14-VIII-2000, em 18 VIII-2000, J. P. Tuttle (USNM); 17♀, 4♂ same data as holotype (USNM).

Etymology.—From the host family stem “bracon” and “voro”, meaning to eat.

Host.—Reared from *Aleiodes* sp. (Braconidae) in larva of *Sagenosoma elsa* on *Lycium pallidum* Miers (Solanaceae).

Discussion.—*Microdontomerus braconivorus* is recognized by its extremely short, barb-like ovipositor (Fig. 1), which is about half the length of the metatibia.

Microdontomerus buprestae Grissell,
new species

Figs. 2, 25, 27, 41, 48

Holotype female.—Body length excluding ovipositor 3.0 mm, ovipositor 1.7 mm. Body black (without metallic sheen) except orange are: scape, tibiae, and tarsi; wings weakly shaded brown in distal 2/3, darker around parastigma and marginal vein. **Head:** Distance between eyes greater

than eye height; clypeus (Fig. 27) projecting beyond lateral corners of oral fossa; ratio of ocellocular distance: postocellar distance: lateral ocellus diameter 4:9:3; dorsum of torulus on line with venter of eyes; toruli about 1 diameter apart; intermalar distance about $1.5\times$ malar distance; eye height about $1.7\times$ malar distance; antenna (Fig. 48) with pedicel laterally over $2.0\times$ as long as broad apically, anellus elongate, subequal to F1, funicle segments wider than long, flagellum parallel-sided, scape not reaching median ocellus, separated from it by about half an ocellus diameter. **Mesosoma:** Scutellum dorsally flat but still convex, not in same plane as scutum; metanotum and propodeum in same plane but angled downward from plane of scutellum; posterior axillular carina narrow; dorsellum convex with slight median carina, with anterior and posterior row of pits (though these difficult to see and dorsellum appearing polished; propodeum covered with raised reticulation, with pits along anterior margin (Fig. 25) (perpendicular carinae present) becoming smaller towards outer margin, with strong but irregular median carinae extending from dorsal margin to nucha, nucha a narrow arched carina, median carina subtended by deep foveae, posterolateral corner of propodeum angulate (but not projecting) with distinct projecting denticle above it; spiracle subequal to own longest inner diameter from posterior margin of metanotum, median length of propodeum about $3\times$ longest inner spiracle diameter; forewing ratio PV:MV:SV:SMV as 10:17:6:45, postmarginal vein about $0.6\times$ marginal vein, costal cell below with 1 to 2 complete anterior setal rows and nearly covered with setae, upper surface without setae; basal setal line complete; cubital setal line with few setae basally (i.e., basal cell partially closed but with complete setal line in paratypes), with partial bare areas paralleling both sides and ending at about midpoint of marginal vein; basal cell with complete setal row; admarginal area not

defined by posterior line of setae and with dense setae above, parastigmal and basal areas bare; stigmal area setose. **Metasoma:** MT2-6 (Fig. 41) deeply emarginate at apico-median margin; ovipositor sheaths shorter than mesosoma plus metasoma, $2.0\times$ as long as metatibia.

Male.—Unknown.

Variation.—The few specimens exhibit no variation.

Type material.—Holotype ♀, 16.2 mi. E Prineville, Crook Co., Oregon, R. W. Westcott, summer 1977, ex *Chrysobothris* sp. in crown of *Erigonum compositum* (USNM); 2 ♀ paratypes with the same data (USNM).

Etymology.—Pertaining to the host family, Buprestidae, from which it has been reared.

Host.—Reared from *Chrysobothris* sp. (Buprestidae) in crown of *Erigonum compositum* Douglas ex Bentham (Polygonaceae).

Discussion.—*Microdontomerus buprestae* belongs to the group of species in which the scutellum is dorsally flattened and smooth (or at least less sculptured in contrast to the anterior of the scutum), the venter of the torulus is low on the face relative to the lower margin of the eye, and the ocellocular distance is greater than the longest lateral ocellus diameter. It is most readily distinguished by a small denticle or angle above the posterolateral corner of the propodeum. This denticle is not at the corner (as in Fig. 22 for *M. gordlii*) but above it (Fig. 25). Also, MT2-6 are deeply emarginate (Fig. 41), a state not found in most Nearctic species of the genus.

Microdontomerus ciscida Grissell,
new species

Figs. 24, 30, 52

Holotype female.—Body length excluding ovipositor 1.9 mm, ovipositor 0.9 mm. Body metallic violet with blue reflections, except yellow are: scape, tibiae, and tarsi; wing veins brownish. **Head:** Distance between eyes slightly greater than eye

height; clypeus about even with lateral corners of oral fossa (Fig. 30); ratio of ocellocular distance: postocellar distance: lateral ocellus diameter 6:11:4; dorsum of torulus slightly above level of lower eye margin; toruli about own diameter apart; intermalar distance about $1.5\times$ malar distance; eye height about $2.0\times$ malar distance; antenna (Fig. 52♂) with pedicel laterally about $2\times$ as long as broad apically, anellus transverse, half as long as F1, funicle segments wider than long, flagellum essentially parallel-sided [based on paratypes, holotype clava collapsed], scape not reaching median ocellus, separated from it by about half an ocellus diameter. **Mesosoma:** Scutellum almost flat, not in same plane as scutum; metanotum and propodeum in same plane but not in same plane as apex of scutellum; posterior axillular carina polished, narrow; dorsellum (Fig. 24) convex, with pits along anterior margin, posteriorly with small pits, medially with carina that appears to connect to median carina; propodeum (Fig. 24) angled with respect to scutellum, with pits along anterior margin (perpendicular carinae present) decreasing in size laterally, with distinct median carina subtended by deep pit on either side, carina extends from dorsal margin to nucha, which is obscured by carinae, posterolateral corner of propodeum somewhat angular and carinate but without distinct projecting denticle; spiracle subequal to own longest inner diameter from posterior margin of metanotum, median length of propodeum about $2.5\times$ longest inner spiracle diameter; forewing ratio PV:MV:SV:SMV as 2:3:1:6, postmarginal vein about $0.6\times$ marginal vein, costal cell below with 1 to 2 complete anterior setal rows and bare lunate area medially, upper surface with 1 or 2 setae at distal apical margin; basal setal line complete; cubital setal line with setae basally (i.e., basal cell closed), with partial bare areas paralleling ventral side, ending at about midpoint of marginal vein; basal cell with complete setal row and addition-

al setae paralleling submarginal vein; ad-marginal area not defined by posterior line of setae and with dense setae above, parastigmal and basal areas bare; stigmal area setose. **Metasoma:** Terga not emarginate at apico-median margin; ovipositor sheaths shorter than metasoma, $1.6\times$ as long as metatibia.

Male.—Body length 1.4–1.7 mm. Color, sculpture, and other characters about as for female except: scape dorsally bluish; eye height about $2.5\times$ malar distance; scape ventrally flat and polished, wider than in female, separated from midocellus by about an ocellus diameter; flagellum spindle-shaped (Fig. 52♂), basal flagellomeres reduced, wider than long, F1–2 “anellus-like”, but with multiporous plate sensilla; clava pointed.

Variation.—Females range in length from 1.9 to 2.3 mm and display little variation except in the propodeum. The median carina of the dorsellum may be fairly obvious (as in the holotype) and appear to extend to the median carina of the propodeum. In some specimens the carina of the dorsellum is reduced and not apparently connected (or overlapping) the median propodeal carina. In females the scape may vary between specimens from yellow to darkish yellow.

Type material.—Holotype ♀, California, Berkeley, 5 Sept. 1937, B. M. Armitage (USNM); 9♀, 3♂ paratypes with same data (USNM).

Etymology.—From “cis”, meaning weevil, and “-cida”, to kill, in reference to the host of this species.

Host.—Reared from larva of *Lixus parvus* (Curculionidae).

Biology.—I have been unable to locate biological information relating to *Lixus parvus*, and there is little information on Nearctic species in general. According to Arnett et al. (2001) *Lixus* adults “. . . are associated with various plants in the Asteraceae and Polygonaceae”. Chittenden (1930) described a species whose larvae lived in the roots of *Pluchea camphorata* (L.)

and another “ovipositing on *Bidens*” (both Asteraceae). Ter-Minasyan (1978) summarized much information for Palearctic species of *Lixus* which “. . . lay eggs in the peduncle or the thinner parts of the stalk . . .” “. . . of the host plant where they are to complete their development”. “Development of the larva and pupation takes place in the host plant”. According to Ter-Minasyan, at least 15 families of plants are host to *Lixus*. In the Palearctic *Lixus* is particularly damaging to cole crops, beets, and many other cultivated plants.

Discussion.—*Microdoutomerus ciscida* belongs to the group of species in which the scutellum is dorsally flattened and smooth (or at least less sculptured in contrast to the anterior of the scutum), the venter of the torulus is low on the face relative to the lower margin of the eye, and the ocellular distance is greater than the longest lateral ocellus diameter. It is similar to *M. mysticus* in having the costal cell above with a row of setae along the anterior margin and the lateral ocellus diameter 1.5 to $2\times$ the ocellular distance. It differs as discussed in the key, and additionally is bright metallic blue to violaceous, whereas *M. mysticus* is black with only slight metallic reflections.

Microdoutomerus darwini Grissell,
new species

Figs. 34, 47

Holotype female.—Body length excluding ovipositor 2.3 mm, ovipositor ca 4.5 mm (curved over body and difficult to measure). Head and thorax brilliant metallic copper with shades of green, metasoma and coxae blackish copper; scape, pedicel, and legs beyond coxae bright orange; tarsi whitish; wing veins dark brown; admarginal area of wing with brown stain extending to basal setal line and cubital setal line. **Head:** Distance between eyes slightly less than eye height; clypeus (Fig. 34) obviously projecting beyond line connecting lateral corners of oral fossa; ratio of ocellular distance: postocellar distance: lat-

eral ocellus diameter 3:10:4; venter of torulus about on line with venter of eyes; toruli about own diameter apart; intermalar distance about $2.2\times$ malar distance; eye height about $2.5\times$ malar distance; antenna (Fig. 47) with pedicel laterally about $2\times$ as long as broad apically, anellus about as long as broad, less than half as long as F1, funicle segments longer than wide (except F7, flagellum parallel-sided, scape nearly reaching median ocellus, clava pointed apically. **Mesosoma:** Scutellum flat, nearly in same plane as apex of scutum, metanotum and propodeum in same plane and almost in same plane as apex of scutellum; posterior axillular carina difficult to see, much reduced; dorsellum convex, with pits along anterior margin; propodeum with regular-sized pits along anterior margin, with indistinct median depression but no carina; posterolateral corner of propodeum smooth, rounded; spiracle subequal to own longest inner diameter from posterior margin of metanotum, median length of propodeum about $3.5\times$ longest inner spiracle diameter; forewing ratio PV:MV:SV:SMV as 3.5:6:2:14, postmarginal vein about $0.5\times$ marginal vein, costal cell below with 1 to 2 complete anterior setal rows and bare lunate area medially, upper surface without setae; basal setal line complete; cubital setal line complete (i.e., basal cell closed), apically with partial bare areas paralleling ventral side, ending at about midpoint of marginal vein; basal cell with complete setal row; admarginal area not defined by posterior line of setae, with dense setae above, parastigmal and basal areas bare; stigmal area asetose. **Metasoma:** Laterally compressed, terga emarginate at apico-median margin; ovipositor sheaths longer than entire body, about $6\times$ as long as metatibia.

Male.—Unknown.

Variation.—The two females are identical.

Type material.—Holotype ♀, California, Inyo County, Darwin Falls, 17 April 1970, E. E. Grissell (UCD), on *Eriogonum infla-*

tum (Polygonaceae); 1♀ paratype with same data (USNM).

Etymology.—This species is named in honor of the incomparable Charles Darwin, and not Darwin French, after whom the type locality was named.

Distribution.—Known only from the type locality.

Host.—No host is known.

Discussion.—This species is unique in having a broadly rounded, projecting clypeus (Fig. 34) and the ovipositor much longer than the entire body and about $6\times$ as long as the metatibia. In other species the clypeus is at most slightly rounded (e.g., Figs. 27, 29) and the ovipositor is at most $2.5\times$ as long as the metatibia. The face appears somewhat narrower than other species (Fig. 34), but it is about as wide as high by actual measurement whereas other species are at least slightly wider than high. In addition *M. darwini* has the flagellomeres mostly longer than broad (Fig. 47), the clava distinctly apically pointed (Fig. 47), and the forewing shaded brown between the marginal and cubital veins.

Microdontomerus eborens Grissell,
new species

Figs. 14, 17, 56

Holotype female.—Body length excluding ovipositor 1.9 mm, ovipositor 0.7 mm. Body black faint blue metallic reflections on head and propodeum; brownish are: lower half of face and mesosoma, coxae, base of metasoma; pale yellow are: basal half of femora; white are: scape, pedicel, flagellum, apical halves of femora, all tibiae, tarsi, wing veins. **Head:** Distance between eyes subequal to eye height; clypeus about on same line as lateral corners of oral fossa; ratio of ocellocular distance: postocellar distance: lateral ocellus diameter 7:21:9; torulus ventrally on line with lower margin of eyes; toruli about 1 diameter apart; intermalar distance about $1.3\times$ malar distance; eye height about $2.3\times$ malar distance; antenna (Fig. 56♀)

with pedicel laterally about as long as broad, anellus distinctly transverse, F1 anellus-like, funicle segments all wider than long, flagellum slightly spindle-shaped, clava apically pointed, scape not reaching median ocellus and separated from it by about $1\times$ ocellus diameter. **Mesosoma:** Scutellum convex, not in same plane as scutum; metanotum and propodeum not in same plane as apex of scutellum; posterior axillular carina narrow, flat, polished, but not flaring triangularly dorsally (Fig. 17); dorsellum convex, with obscure wrinkled sculpture and carinae; propodeum with row of pits along apical margin, pits largest medially growing smaller laterally, medially with complete delicate, nucha a narrow, lunate polished carina, posterolateral corner of propodeum rounded; spiracle slightly less than own longest inner diameter from posterior margin of metanotum, median length of propodeum about $3\times$ longest inner spiracle diameter; forewing (Fig. 14) ratio PV: MV:SV:SMV as 2:3:1:7, postmarginal vein about $0.6\times$ marginal vein, costal cell below with 2 to 3 complete anterior setal rows, essentially covered except for small lunate area medially, upper surface without setae; basal setal line complete; cubital setal line complete (i.e., basal cell closed) with bare areas paralleling either side and ending about midpoint relative to marginal vein; basal cell with complete anterior setal row paralleling submarginal vein; admarginal area not defined by posterior line of setae, with dense setae above, parastigmal area and basal area bare; stigmal area with setae. **Metasoma:** Terga without apico-median emarginations; ovipositor sheath shorter than metasoma, about $1.3\times$ as long as metatibia.

Male.—Body length 1.2 to 2.0 mm. About as for female except: flagellum distinctly spindle-shaped (Fig. 56♂); F1-3 reduced, nearly anelliform; in some specimens scape and flagellum with slight black infusion; basal half of femora infused with brown.

Variation.—Females vary in length from 1.6 to 2.4 mm. In some females the basal halves of femora are infused with brown. In both sexes the dorsellum varies from more or less smooth to having obscure wrinkles or carinae.

Type material.—Holotype ♀, 11 mi. N Portal, Cochise Co., Arizona, A. Zvirgzdins, 20 June 1976, ex *Deopalpus contiguus* on *Eucaterva variaria* (USNM); 5♀, 3♂ paratypes, same data; 2♀, 2♂ paratypes, same data except 27 January 1976 (USNM).

Etymology.—From *eboreus*, meaning "of ivory", with reference to the white legs and antennae.

Distribution.—Known only from Cochise County in Arizona.

Host.—Reared from *Deopalpus contiguus* (Tachinidae) a primary parasitoid of *Eucaterva variaria* (Geometridae).

Biology.—*Microdontomerus eboreus* appears to be a hyperparasitoid of geometrids through their tachinid parasitoid. *Microdontomerus gordii* was reared from the same geometrid host, but no mention was made of intermediary tachinids. Perhaps *M. gordii* is a primary parasitoid and the two species have complimentary biologies with regard to the same primary host.

Discussion.—*Microdontomerus eboreus* is similar in appearance to *M. gordii* with respect to the spindle-shaped antenna with clava apically pointed, the pedicel about as long as wide, and especially the axillular carina being slightly flattened, widened, and polished. In *M. eboreus* the axillular carina is parallel-sided but not expanded dorsally (Fig. 17), whereas in *M. gordii* it expands dorsally into a triangular polished area (Fig. 18). Additionally, *M. eboreus* has the posterolateral corners of the propodeum rounded, whereas they are angulate in *M. gordii* (Fig. 22). *Microdontomerus eboreus* is the only species in which the female and male have the antennae and legs (except sometimes bases of femora) concolorous white.

Microdontomerus enigma Grissell,
new species
Figs. 7, 33, 43

Holotype female.—Body length excluding ovipositor 2.5 mm, ovipositor 2.2 mm. Body black with metallic green reflections except as follows: orange are: scape, all tibiae; brown are: wing veins, ovipositor sheaths; whitish are: all tarsi. **Head:** Distance between eyes subequal to eye height; clypeus (Fig. 33) projecting slightly beyond lateral corners of oral fossa; ratio of ocellular distance: postocellar distance: lateral ocellus diameter 8:18:5; torulus barely above lower margin of eyes; toruli about 1 diameter apart; intermalar distance about $2.3\times$ malar distance; eye height about $2.5\times$ malar distance; antenna (Fig. 43♀) with pedicel laterally about $1.5\times$ as long as broad apically, anellus transverse though slightly elongate, funicle segments slightly wider than long, flagellum slightly wider distally than proximally but essentially parallel-sided, scape not reaching median ocellus and separated from it by about an ocellus diameter. **Mesosoma:** Scutellum convex, not in same plane as scutum; metanotum and propodeum not in same plane as apex of scutellum; posterior axillular carina reduced and narrow; dorsellum more or less flat, with obscure median carina and lateral carinae that divide it into 4 weak depressions; propodeum with pits along anterior margin (perpendicular carinae present), medially flattened, with distinct carina extending from dorsal margin to nucha, nucha a narrow, arched polished carina, posterolateral corner of propodeum rounded, without distinct projecting denticle; spiracle subequal to own longest inner diameter from posterior margin of metanotum, median length of propodeum about $3\times$ longest inner spiracle diameter; forewing (Fig. 7) ratio PV:MV:SV:SMV as 13:18:6:45, postmarginal vein about $0.75\times$ marginal vein, costal cell below with 1 to 2 complete anterior setal rows, upper sur-

face without setae; basal setal line essentially bare; cubital setal line bare basally (i.e., basal cell open), with partial bare areas paralleling either side, dorsal and ventral areas ending at about midpoint of marginal vein; basal cell without setae; admarginal area not defined by posterior line of setae and with 7 or 8 wide spaced setae above, parastigmal and basal areas bare; stigmal area with setae. **Metasoma:** MT2 faintly emarginate at apico-median margin; other terga entire; ovipositor sheaths slightly shorter than length of meso- plus metasoma, $2.2\times$ as long as metatibia.

Male.—Body length 2.0 mm. Color, sculpture, and other characters about as for female except: eye height about $3\times$ malar distance; scape ventrally flat and polished; flagellum distinctly widening apically (Fig. 43♂), flagellomeres wider than long; cubital setal line may be complete basally.

Variation.—Females vary in range from 2 to 3 mm. The ovipositor is constant at about $2\text{--}2.2\times$ as long as the metatibia. Some female specimens have a few (1 to 3) bristles on the basal part of the cubital vein or in the basal cell, but generally the basal part of the wing is relatively asetose.

Type material.—Holotype ♀ Nixon, Washoe Co., Nevada, ex cell *Hoplitis bullifacies*, [no date] Frank Parker (# 3752H) (USNM); 21♀, 4♂ paratypes (deposited in USNM and USU): 6♀, 1♂ same data as holotype; 7♀ same data except Patrick, #3727B; 2♀ same data except #3727H; 6♀, 3♂ same data except #3836C.

Etymology.—From “*enigma*”, Latin for “obscure”, in reference to the cryptic nature of this species.

Distribution.—*Microdontomerus enigma* is known only from Washoe County, Nevada.

Hosts.—All specimens were reared from *Hoplitis bullifacies* (Megachilidae).

Discussion.—This species is phenotypically nearly identical to *M. parkeri*. In *M. enigma* the postmarginal vein (Fig. 7) is

about $0.75\times$ as long as the marginal vein (about $0.5\times$ in *M. parkeri*, Fig. 6) and the admarginal area (Fig. 7) is not well delimited posteriorly and is covered with wide-spaced setae (well delimited posteriorly and with few setae in *M. parkeri*, Fig. 6). Somewhat more difficult to assess is that in *M. enigma* the longest diameter of the lateral ocellus is less than the ocellocular distance, whereas it is subequal to or greater than in *M. parkeri* (Fig. 39).

***Microdoutomerus fumipennis* Crawford**

Microdoutomerus fumipennis Crawford 1916:141–142. Lectotype ♀, designated by Grissell (1995: 204), Maxwell, New Mexico (USNM, examined); 7♀, 3♂ paralectotypes same as lectotype.

Lectotype female.—[Characters in brackets are from the paralectotypes because the lectotype has some areas covered by glue.] Body length excluding ovipositor 3.0 mm, ovipositor 1.4 mm. Body black without metallic reflections; orange are: scape, pedicel, apices of femora, tibiae, tarsi; brownish are: wing veins; central area of forewing. **Head**: Distance between eyes slightly greater than eye height; clypeus on same line as lateral corners of oral fossa; ratio of ocellocular distance: postocellar distance: lateral ocellus diameter 7:18:7; venter of torulus at lower margin of eyes; toruli about 1 diameter apart; intermalar distance about $1.5\times$ malar distance; eye height about $2\times$ malar distance; antenna with pedicel laterally about $1.5\times$ long as broad, anellus distinctly transverse, funicle segments all wider than long, flagellum parallel-sided, scape barely reaching median ocellus. **Mesosoma**: Scutellum convex, not in same plane as scutum; metanotum and propodeum not in same plane as apex of scutellum; posterior axillular carina reduced and narrow; dorsellum more or less flat, with strong irregular carinae dividing it into many irregular pits; [propodeum with row of pits along apical margin, pits largest medially growing smaller laterally, medially with

complete strong carina, nucha a narrow, lunate polished carina, posterolateral corner of propodeum rounded; spiracle subequal to own longest inner diameter from posterior margin of metanotum, median length of propodeum about $3\text{--}4\times$ longest inner spiracle diameter]; forewing ratio PV:MV:SV:SMV as 9:13:5:30, postmarginal vein about $0.7\times$ marginal vein, costal cell below with 2 to 3 complete anterior setal rows, essentially covered except for small lunate area medially, upper surface without several setae along anterior margin; basal setal line complete; cubital setal line setose in basal cell (i.e., basal cell closed), with bare areas paralleling either side and ending at about midpoint of marginal vein; basal cell with incomplete anterior setal row paralleling submarginal vein; admarginal area not defined by posterior line of setae, evenly covered with setae, parastigmal area and basal area bare; stigmal area with setae. **Metasoma**: [MT2-3 entire, without emargination at apico-median margin], remaining terga entire; ovipositor sheaths shorter than metasoma, about $1.5\times$ as long as metatibia.

Paralectotype males.—Body length 1.5 to 2.0 mm. About as for female except: flagellum slightly wider apically; scape ventrally flattened and polished; F1 reduced, nearly anelliform.

Variation.—Females in the type series range from 2 to 3 mm excluding the ovipositor. Other material examined ranges from 1.5 to 3.5 mm. The amount of shading in the forewing varies from weakly to strongly stained.

Material examined.—I have seen 83♀ and 7♂ from the following locations (all in USNM unless marked otherwise): Arizona: Pima Co.: 2♀ Sabino Canyon, 6 April 1957, F. Werner, G. Butler, ex cocoons *Malacosoma fragile*; 1♀ same data except, 25 April 1953, 1965, ex. *Malacosoma* sp.; 1♀ Tucson, 8 April 1971, R. Robbins, ex cocoon *Malacosoma incurva*; 6♀, 2♂ [no town], Hwy. 83, em. 18–21 June 1984, ex. Ophioninae cocoon in cocoon of *Agapema*

galbina anona. California: Napa Co.: 21 ♀ Glen Ellen, ex pupa "*Hem. vetusta*" (= *Orgyia vetusta*) (UCR); San Luis Obispo Co.: 9 ♀ 6 mi. SE Pozo, 23 April 1989, W. E. Wahl; Santa Barbara Co.: 1 ♀ Bluff Camp, San Rafael Mts., 29 June 1959, P. M. Marsh (UCD); Solano Co.: 2 ♀ Cold Canyon Reserve, 11 km W Winters, 7–17 May 1991, D. Carmean, Malaise trap (UCD); 1 ♀ same locality, 17 July 1993, S. L. Heydon, on *Dacus* sp. (UCD); Sonoma Co.: 11 ♀, 1 ♂ [no town], ex *Clisiocampe thoracica*; Tuolumne Co.: 1 ♀ Tuolumne City, 25 June 1971, N. J. Smith (UCD). Colorado: Arapahoe Co.: 1 ♀ [no town], S. Yosemite Str., coll. 25 July 1992, T. Eckberg, em. August 1982, ex *Exorista mella*; Costilla Co.: 3 ♀, 1 ♂ Jarosa, Sept. 1985, S. Stone, D. Swift, ex *Hemileuca magnifica* (or hyper in tachinid). Montana: Ravalli Co.: 4 ♀ Darby, 31 July 1922, ex fruit tree leafroller. New Mexico: Union Co.: 5 ♀ Clayton, 28 Sept. 1976, E. Huddleston, ex *Hemileuca oliviae*. Oregon: Josephine Co.: 2 ♀, 2 ♂ Kerby, July 1938, R. L. Furniss, *Canotilus* sp.; Klamath Co.: 3 ♀, 1 ♂ Cave Mountain, 2 June 1985, ex *Rhyacionia zonata* on *Pinus ponderosa*. Utah: Salt Lake Co.: 3 ♀, 1 ♂ Granite, 5 July 1936, W. M. Allen, ex dewberry leafroller; 1 ♀ Monroe, 7 November 1967, Baker-Sandin, ex *Malacosoma*. Washington: Stevens Co.: 1 ♀ Northport, 4 June 1930, DeDelon, ex *Hemerocampa pseudotsugae*; 1 ♀ same, ex ichneumonid in tussock moth pupa. Wyoming: Albany Co.: 1 ♀ Medicine Bow National Forest, along Happy Jack Hwy., coll. 27–28 June 2000, em. 3–10 July 2000, S. Shaw, ex ?*Aleiodes malacosomat* in larva of *Malacosoma disstria*; Sublette Co.: 1 ♀ Pinedale, 26 June 1961, Stehr, *Malacosoma californica*; county unknown: 1 ♀, 1 ♂ Lyle, 28 June 1936, R. L. Furniss, on *Quercus garryana*.

Distribution.—This species is widespread in the western United States.

Hosts.—The type series was reared from *Malacosoma fragile* (now = *californicum fragile*) (Lasiocampidae). Knowlton and Allen (1937) reported it from *Choristoneura*

rosaceana (Tortricidae). Niwa (1988) reared it from *Rhyacionia zonana* (Tortricidae) (examined) on *Pinus ponderosa* C. Lawson (Pinaceae). Peigler (1985) reported it from an Ophioninae cocoon (Ichneumonidae) within the cocoon of *Agapena galbina anona* (Saturniidae) (examined) and from *Hemileuca magnifica* (Saturniidae) (Peigler 1994). Witter and Kulman (1972) summarized earlier literature resources for this species.

New rearing records for this species are (all USNM unless otherwise stated): *Exorista mella* (Tachinidae); *Hemileuca olivae* (Saturniidae), *Orgyia pseudotsugata*, *O. vetusta* (Lymantriidae) (UCR); *Archips argyrospila* (fruittree leafroller) (Tortricidae); *Malacosoma incurvum*, *Malacosoma disstria* (Lasiocampidae) (probably from *Aleiodes malacosomat* (Braconidae) in the larval host mummy); ichneumonid in tussock moth (Lasiocampidae).

Biology.—Witter and Kulman (1972) treated *M. fumipennis* as an egg parasite based upon Langston (1957), but Langston does not mention anything about life stages attacked so the notion is completely invalid. Peigler (1985) demonstrated that this species was a hyperparasite, possibly in a facultative manner. Scott Shaw (pers. comm.) reared this species from suspected *Aleiodes malacosomat* (Hym: Braconidae) in the larval host mummy of *Malacosoma disstria*. Niwa (1988) reported *M. fumipennis* as an extremely rare parasitoid (4 specimens from 4500 host pupae) which attacked host pupae in the fall and emerged in the spring.

Discussion.—In 1995 I designated a lectotype for this species (Grissell 1995) without giving a reason for doing so. Crawford (1916) described this species from 8 females and 3 males without designating a specimen as holotype. To insure nomenclatural stability I selected a single female as lectotype.

Microdontomerus fumipennis appears similar to *M. gordlii* in size and coloration. The former, however, has the costal cell

setose along the dorsal anterior margin and the latter does not. Additionally, *M. fumipennis* has a narrow axillular carina (as in Fig. 16) as opposed to the widened carina in *M. gordhi* (Fig. 18) and the forewing is lightly infumate posterior to the marginal vein, whereas it is hyaline in *M. gordhi*. In *M. fumipennis* the ovipositor is about 1.4 to 1.5 \times the metatibia, whereas in *M. gordhi* it is about 1.1 to 1.2 \times the metatibia.

Microdontomerus gordhi Grissell,
new species

Figs. 11, 18, 22, 51

Holotype female.—Body length excluding ovipositor 2.4 mm, ovipositor 0.7 mm. Body black without metallic reflections; orange are: scape, pedicel, flagellum, apices of femora, all tibiae; whitish are: all tarsi, wing veins. **Head**: Distance between eyes slightly greater than eye height; clypeus on same line as lateral corners of oral fossa; ratio of ocellocular distance: post-ocellar distance: lateral ocellus diameter 6:17:7; torulus slightly above lower margin of eyes; toruli about 1 diameter apart; intermalar distance about 1.5 \times malar distance; eye height about 2 \times malar distance; antenna (Fig. 51♀) with pedicel laterally about as long as broad, anellus distinctly transverse, funicle segments all wider than long, flagellum more or less parallel-sided, scape not reaching median ocellus and separated from it by about 0.5 \times ocellus diameter. **Mesosoma**: Scutellum convex, not in same plane as scutum; metanotum and propodeum not in same plane as apex of scutellum; posterior axillular carina wide, flat, and polished (Fig. 18); dorsellum convex, with obscure wrinkled sculpture and carinae; propodeum with row of pits along apical margin, pits largest medially growing smaller laterally, medially with complete delicate carina, nucha a narrow, lunate polished carina, posterolateral corner of propodeum distinctly angulate (Fig. 22); spiracle about 0.5 \times own longest inner diameter from

posterior margin of metanotum, median length of propodeum about 3 \times longest inner spiracle diameter; forewing (Fig. 11) ratio PV:MV:SV:SMV as 2:3:1:7, postmarginal vein about 0.7 \times marginal vein, costal cell below with 2 to 3 complete anterior setal rows, essentially covered except for small lunate area medially, upper surface without setae; basal setal line complete; cubital setal line sparsely setose in basal cell (i.e., basal cell closed based on paratypes), with bare areas paralleling either side and ending at about midpoint of marginal vein; basal cell with complete anterior setal row paralleling submarginal vein; admarginal area not defined by posterior line of setae, evenly covered with setae, parastigmal area and basal area bare; stigmal area with setae. **Metasoma**: MT2-3 slightly emarginate at apico-medial margin, remaining terga entire; ovipositor sheaths shorter than metasoma, about 1.2 \times as long as metatibia.

Male.—Body length 1.7 mm. Similar to female except: flagellum spindle-shaped (Fig. 51♂); F1 reduced, nearly anelliform; cubital vein complete (i.e., not interrupted at junction with basal vein).

Variation.—Females vary in length from 2.4 to 2.7 mm and the ovipositor from about 1.1 to 1.2 \times the metatibia. The cubital vein of the holotype is interrupted (i.e., bare with several setae missing) at its junction with the basal vein, but in some specimens it appears that only one or two setae are missing. The basal cell is basically "closed" posteriorly, but to varying degrees of completeness. The pit on either side of the median carina varies from nearly absent (indicated by a carina and slight depression) to nearly as strong as shown in Fig. 15.

Type material.—Holotype ♀, California, Riverside Co., Whitewater Canyon, October 1978, G. Gordh, ex pupa *Eucaterva variaria* (USNM); 16♀, 1♂ paratypes with same data (UCR, USNM).

Etymology.—Named for Gordon Gordh, the collector.

Host.—Reared from *Eucaterpa variaria* (Geometridae).

Discussion.—*Microdontomerus gordii* is similar in appearance to *M. fumipennis* especially in the dense setation of the admarginal area of the forewing. Methods to separate the two species are given under the latter. Additionally in *M. gordii* the lateral corners of the propodeum are angulate and slightly projecting (Fig. 22) whereas in other species (except *M. buprestae*, Fig. 25) they are at most broadly acute (Figs. 23, 24).

Microdontomerus hemileucae Grissell,
new species

Figs. 10, 32, 50

Holotype female.—Body length excluding ovipositor 1.5 mm, ovipositor 0.7 mm. Body black except as follows: pale yellow are: scape, fore and mesotibiae (metatibia shaded to black); brown are: flagellum; whitish are: tarsi, wing veins. Head and mesosoma (excluding metanotum) nearly evenly covered with reticulate sculpture; metasomal terga finely, distinctly reticulate laterally and dorsally. **Head**: Distance between eyes subequal to eye height; clypeus (Fig. 32) on line with lateral corners of oral fossa; ratio of ocellocular distance: postocellar distance: lateral ocellus diameter 1:3:1; torulus slightly less than own diameter above lower margin of eyes; toruli about 1 diameter apart; intermalar distance about $1.8\times$ malar distance; eye height about $3\times$ malar distance; antenna (Fig. 50) with pedicel laterally about as long as broad apically, anellus distinctly transverse, F1 ringlike but with placoids, funicle segments all wider than long, flagellum slightly wider distally than proximally, scape not reaching median ocellus and separated from it by about one ocellus diameter. **Mesosoma**: Scutellum convex, not in same plane as scutum; metanotum and propodeum not in same plane as apex of scutellum; posterior axillular carina reduced, inconspicuous; dorsellum somewhat convex, with obscure wrinkled

sculpture in upper half, posterior margin transversely depressed; anteromedian area of propodeum without pits, but pits begin laterally near lateral edge of dorsellum, medially with complete carina reaching to nucha, nucha a narrow, lunate polished carina, posterolateral corner of propodeum rounded, without distinct projecting denticle; spiracle about $1\times$ own longest inner diameter from posterior margin of metanotum, median length of propodeum about $3\times$ longest inner spiracle diameter; forewing (Fig. 10) ratio PV: MV:SV:SMV as 17:30:10:67, postmarginal vein about $0.6\times$ marginal vein, costal cell below with 2 to 3 complete anterior setal rows, essentially covered except for small lunate area medially, upper surface without setae; basal setal line complete; cubital setal line complete (i.e., basal cell closed), with bare areas paralleling either side, dorsal area ending at about midpoint relative to marginal vein, ventral area ending at about apex relative to marginal vein; basal cell with partial anterior setal row paralleling submarginal vein; admarginal area defined posteriorly by irregular row of setae, area with 3 or 4 setae, parastigmal area and basal area bare; stigmal area with narrow bare surface to apex of postmarginal vein. **Metasoma**: Terga without emarginations at apico-median margin; ovipositor sheaths shorter than metasoma, $1.3\times$ as long as metatibia.

Male.—Body length 1.0 to 1.7 mm. Color, sculpture, and other characters as for female except: distance between eyes less than eye height; eye height nearly $4\times$ malar distance.

Variation.—Females vary in length from 1.3 (ovipositor 0.6) to 1.9 (ovipositor 0.7) mm. In smaller female and all male specimens the distance between the eyes becomes slightly narrower than the eye height.

Type material.—Holotype ♀, 7 mi. E El Sueco, Chihuahua Municipality, Chihuahua State, June 1983, G. Fritz, ex eggs of *Hemileuca oliviae* (USNM); 54♀, 16♂ para-

types, same data as holotype (USNM, CNC, BMNH).

Other material examined.—Mexico: Baja California Sur: 2♀, 4♂ San Ignacio, 25 August 1994, S. L. Heydon (UCD).

Etymology.—Named for its association with the range caterpillar, *Hemileuca oliviae*.

Distribution.—The species is known so far only from northern Mexico (Chihuahua, Baja California Sur).

Hosts.—This species was reared from eggs of *Hemileuca oliviae* (Saturniidae) and from eggs of an unknown, field-collected pentatomid (reported in Fritz et al. 1986). I have not seen material reared from the pentatomid.

Biology.—Although this species was reared from eggs of *Hemileuca oliviae* it is not certain if it is a true egg parasitoid or possibly a hyperparasitoid (Peigler 1994). The eggs of *H. oliviae* are commonly infested with the parasitoid *Anastatus semiflavus* (Eupelmidae) (Watts and Everett 1976, Fritz et al. 1986, Mendel et al. 1987). Evidence from egg dissections proved inconclusive, but Fritz et al. (1986) demonstrated that both *A. semiflavus* and *M. hemileuca* (as *Microdontomerus* sp.) parasitized embryonated eggs. From field collected *Hemileuca* eggs Fritz et al. (1986) reared 1367 adults of *Anastatus* but only 102 adults of *Microdontomerus*. Much reduced numbers of the latter relative to the former is a possible indication of hyperparasitism. Perhaps significantly, *M. hemileuca* did not oviposit into or emerge from laboratory reared eggs of *Hemileuca*, whereas *A. semiflavus* did, thus indicating possible hyperparasitoid behavior for *M. hemileuca* (Fritz et al. 1986). Watts and Everett (1976) noted that *A. semiflavus* had been an important natural enemy of *H. oliviae*, but that its effectiveness had decreased by the 1970's. They did not find any egg parasitoid other than *A. semiflavus*. *Microdontomerus hemileuca* was first discovered in the early 1980's (Fritz et al. 1986) and may have been a factor in the

decline of *A. semiflavus* and its effectiveness.

Fritz et al. (1986) reared both *A. semiflavus* and *M. hemileuca* from field collected pentatomid eggs and suggested that the pentatomid might serve as an alternate host. Coreid eggs were reported to be parasitized by *A. semiflavus* (Watts and Everett 1976) and thus also might be an expected host for *M. hemileuca* as well.

In *Microdontomerus*, egg parasitism is known for *M. ovivorus* (Steffan) reared from buprestid eggs in Algeria (Steffan 1967) and for *M. senegalensis* (Risbec) reared from praying mantid egg cases in Senegal (Risbec 1951). Material of *M. senegalensis* later reported by Risbec (1954) and examined by me, contained an associated specimen of *Podagrion* (Torymidae), which is a common parasitoid of mantid eggs, and thus it is possible that *M. senegalensis* is a parasitoid of *Podagrion* rather than of the mantid eggs themselves.

Discussion.—*Microdontomerus hemileuca* keys out with *M. bicoloripes* based on their sparsely setose admarginal area of the forewing and lack of dorsal anterior setal row in the costal cell. The characters given in the key will further aid in separating the two species. In addition the two species are distinct in coloration, with the former having pale yellow markings with the metatibia nearly black and the latter having orange markings with the metibia orange.

Microdontomerus mysticus Grissell,
new species

Figs. 3, 12, 35, 42

Holotype female.—Body length excluding ovipositor 3.5 mm, ovipositor 1.0 mm. Body black with very slight metallic bluish purple reflections except orange are: scape, pedicel, tibiae, and tarsi; wings weakly shaded brown in distal $\frac{3}{4}$. **Head:** Distance between eyes subequal to eye height; clypeus (Fig. 35) projecting beyond lateral corners of oral fossa; ratio of ocellular distance: postocellar distance: lat-



mysticus

3



zoyphius

4

Figs. 3–4. *Microdontomerus* spp.; female habitus.

eral ocellus diameter 4:8:3; dorsum of torulus about half own diameter lower than eyes; toruli about 1 diameter apart; intermalar distance about $2.0\times$ malar distance; eye height about $2.0\times$ malar distance; antenna (Fig. 46) with pedicel laterally about

$2\times$ as long as broad apically, anellus quadrate, slightly shorter than F1, funicle segments wider than long, flagellum essentially parallel-sided, scape not reaching median ocellus, separated from it by about an ocellus diameter. **Mesosoma:**

Scutellum flat, not in same plane as scutum; metanotum and propodeum flat and in same plane but not in same plane as apex of scutellum; posterior axillular carina reduced and narrow; dorsellum convex, without median carina or pits; propodeum subhorizontal, with several small pits along anterior margin (perpendicular carinae present), with distinct median carina subtended by deep pits on either side, carina extends from dorsal margin to nucha, which is narrow, arched carina, posterolateral corner of propodeum rounded, without distinct projecting denticle; spiracle subequal to own longest inner diameter from posterior margin of metanotum, median length of propodeum about $3\times$ longest inner spiracle diameter; forewing (Fig. 12) ratio PV:MV:SV:SMV as 8:15:6:40, postmarginal vein about $0.5\times$ marginal vein, costal cell below with 1 to 2 complete anterior setal rows and nearly covered with setae, upper surface with setae row along distal $2/3$ of apical margin; basal setal line complete; cubital setal line with setae basally (i.e., basal cell closed), with partial bare area paralleling ventral side (but not dorsal), ending at about midpoint of marginal vein; basal cell with complete setal row and additional setae paralleling basal setal line; admarginal area not defined by posterior line of setae and with dense setae above, parastigmal and basal areas bare; stigmal area setose. **Metasoma:** MT2 (Fig. 42) slightly emarginate at apico-median margin, other terga without emarginations; ovipositor sheaths shorter than metasoma, $1.4\times$ as long as metatibia.

Male.—Unknown.

Variation.—The few females at my disposal show little variation. The forewing shading appears strongest in the holotype and absent in several other specimens as well as the material from *Crossidius*. One specimen from the latter host has the ovipositor nearly $1.8\times$ as long as metatibia. The two specimens from *Crossidius* appear to have the pedicel slightly narrower (and

thus relatively longer) in dorsal view than specimens from *Dudleya*.

Type material.—Holotype ♀, "Mexico, San Ysidro, Cal.", 22 September 1947, "ex *Dudleya*" (USNM); 5♀ paratypes with same data (USNM). 2♀ paratypes, Nevada, Elko Co., 10 mi. SE Halleck, 27-VIII-1959, Bechtel, Kingsolver, coll., ex pupae of *Crossidius hirtipes*.

Etymology.—From "*mysticus*", Latin for "secret", in reference to the inexact locality and host data for the holotype.

Distribution.—The species is known from Nevada, but the other locality record is cryptic. San Ysidro is located in San Diego County near the Mexican/California border at Tijuana. According to Rick Westcott (pers. comm.) the specimens were probably "from material intercepted at the border station" and really came from NW Baja California.

Host.—Specimens reared from the plant *Dudleya* (Crassulaceae) have no stated host. According to Rick Westcott (pers. comm.) an undescribed species of *Chrysobothris* (Buprestidae) is known from *Dudleya* in the San Diego/Baja area. Additionally, according to Westcott, a pyralid moth and an anobiid beetle also have been reared from the host plant. Given the very similar appearance and flattened habitus of this species relative to *M. westcotti* and *M. buprestae*, both of which attack buprestids, and *M. ciscida*, which attacks weevils, I suspect that *M. mysticus* most likely attacks beetles. Its rearing from pupae of *Crossidius hirtipes* (Cerambycidae) suggests that it may be a generalist on plant boring beetle larvae.

Discussion.—*Microdontomerus mysticus* belongs to the group of species in which the scutellum is dorsally flattened and smooth (or at least less sculptured in contrast to the anterior of the scutum), the venter of the torulus is low on the face relative to the lower margin of the eye, and the ocellocular distance is greater than the longest lateral ocellus diameter. In size and coloration, *M. mysticus* is phenotypi-

cally similar to *M. buprestae*, but differs from that species by characters given in the key. It keys to the same couplet as *M. ciscida*, but differs as discussed under that species. Additionally, *M. mysticus* is nearly twice as long as the latter species.

Microdontomerus parkeri Grissell,
new species

Figs. 6, 23, 28, 39, 55

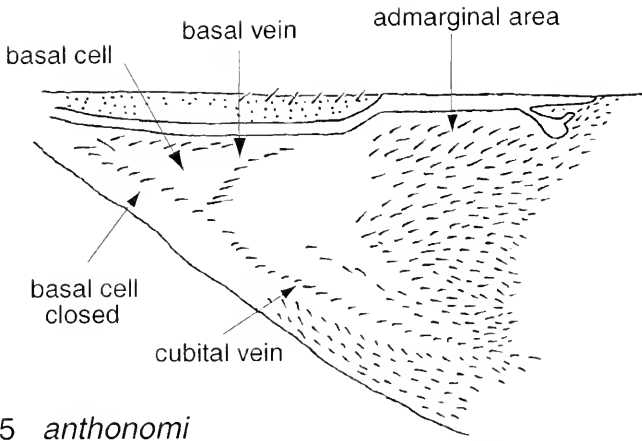
Holotype female.—Body length excluding ovipositor 3.1 mm, ovipositor 1.8 mm. Body black with metallic green reflections except as follows: orange are: scape, pedicel, all tibiae, forefemur, apical half of meso- and metafemora; brown are: wing veins, ovipositor sheaths; whitish are: all tarsi. **Head**: Distance between eyes shorter than eye height; clypeus (Fig. 28) projecting slightly beyond lateral corners of oral fossa; ratio of ocellocular distance: post-ocellar distance: lateral ocellus diameter 10:28:11 (Fig. 39); torulus less than own diameter above lower margin of eyes; toruli about 1 diameter apart; intermalar distance about $1.8\times$ malar distance; eye height about $2.3\times$ malar distance; antenna (Fig. 55) with pedicel laterally about $1.5\times$ as long as broad apically, anellus distinctly transverse, funicle segments all wider than long, flagellum slightly wider distally than proximally but appearing essentially parallel-sided, scape not reaching median ocellus and separated from it by about half an ocellus diameter. **Mesosoma**: Scutellum convex, not in same plane as scutum; metanotum and propodeum not in same plane as apex of scutellum; posterior axillular carina reduced and narrow; dorsellum (Fig. 23) more or less flat, with distinct median carina and lateral carinae that divide it into 3 or 4 deep irregular depressions; propodeum (Fig. 23) laterally with pits along anterior margin (perpendicular carinae present), medially flattened, with distinct carina extending from dorsal margin about half way where it forks, left fork strongly branched to nucha, right fork weak and obscure, nucha a

narrow, arched polished carina, postero-lateral corner of propodeum rounded, without distinct projecting denticle; spiracle subequal to own longest inner diameter from posterior margin of metanotum, median length of propodeum about $3\times$ longest inner spiracle diameter; forewing (Fig. 6) ratio of PM:MV:SV:SMV as 17:35:9:70, postmarginal vein about $0.5\times$ as long as marginal vein; costal cell below with 1 to 2 complete anterior setal rows, upper surface without setae; basal setal line essentially bare with 1 or 2 setae; cubital setal line bare basally (i.e., basal cell open), with partial bare areas paralleling either side, dorsal and ventral areas ending at about midpoint of marginal vein; basal cell with several setae basally, but no row; admarginal area defined by posterior line of setae and with 5 setae above, appearing almost bare, parastigmal and basal areas bare; stigmal area bare to apex of postmarginal vein. **Metasoma**: MT2 slightly emarginate at apico-median margin; other terga entire; ovipositor sheaths subequal in length to metasoma, $2.0\times$ as long as metatibia.

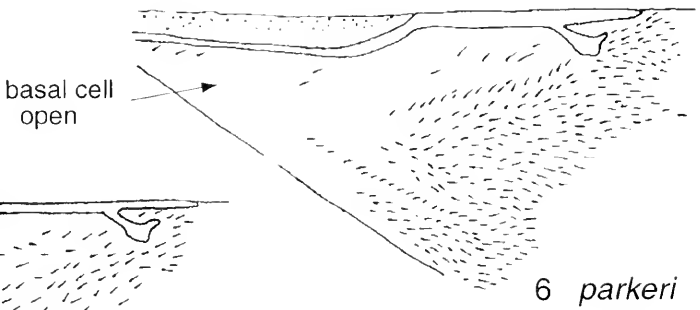
Male.—Body length 1–2 mm. Color, sculpture, and other characters about as for female except: scape ventrally flat and polished; basal setal line may be nearly complete.

Variation.—Females vary in range from 1.5 to 3.0 mm. In females, individuals from single rearings appear to range in length about as follows: 1.5–2.0 mm; 2.0–2.5 mm; 2.5–3.0; and 2.0–3.0 mm; (number of populations sampled = 45). I did not see any populations in which the extremes (ca. 1.5 to 3.0 mm) were found. In all cases, the female ovipositor averaged about $2\times$ the metatibia in length. Males were always slightly smaller. The lateral ocellus diameter ranged from slightly smaller to slightly larger than the ocellocular distance.

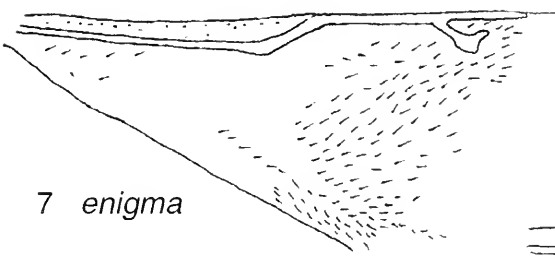
Both body and leg color are extremely variable within and between populations of this species. Body color in larger spec-



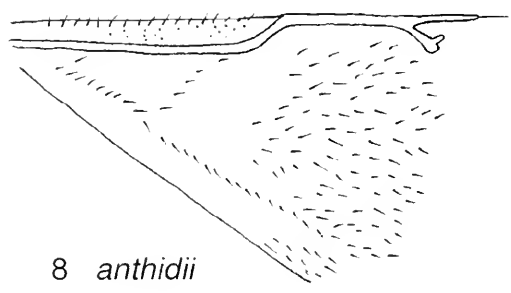
5 *anthonomi*



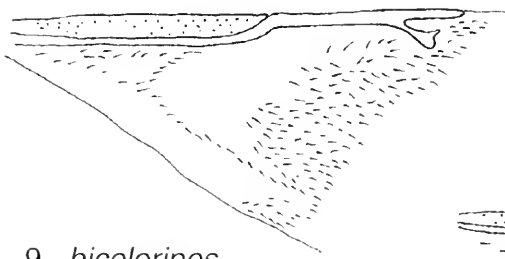
6 *parkeri*



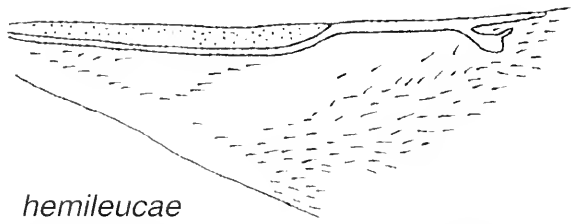
7 *enigma*



8 *anthidii*

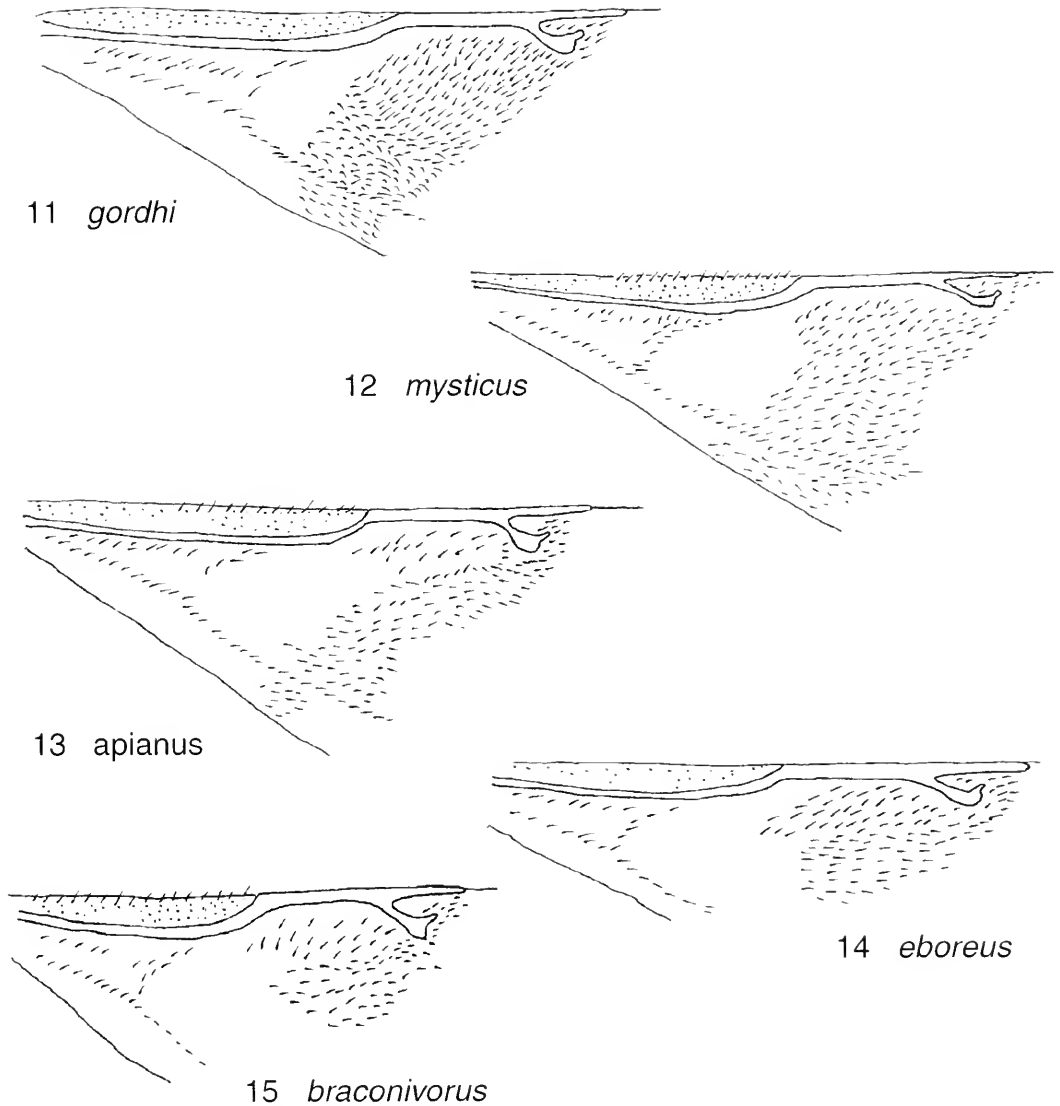


9 *bicoloripes*



10 *hemileuca*

Figs. 5-10. *Microdontomerus* spp., basal portion of forewing, dorsal view showing setation (except costal cell also showing ventral setation as dots).



Figs. 11–15. *Microdontomerus* spp., basal portion of forewing, dorsal view showing setation (except costal cell also showing ventral setation as dots).

imens (over 2.5 mm) varies from black with green metallic reflections, to coppery or reddish green. In smaller specimens the body is generally black but some specimens may have metallic green reflections. The leg (excluding coxae) coloration varies from all orange to various gradations of orange on the femora as follows: forefemur orange in apical half (black basally) with mid and metafemora orange; forefe-

mur tipped orange with meso- mid and metafemora orange; fore- and mesofemora black tipped orange with hind femora orange; all femora black with the apex straw color.

The wing setation is slightly variable around the basic pattern shown in Fig. 6. The basal cell may have 4 or 5 setae, the basal setal line may have 3 or 4 setae, and the admarginal area may have a couple

more or less setae than shown. The ad-marginal area may be posteriorly defined by a distinct, single straight row of setae or this line may be slightly obscure, but it is a distinct largely bare area with few setae. The stigmal area is usually bare, but occasional specimens will have at most one seta in the area. The basal cell is always open posteriorly. In general the wing appears bare in the basal half, regardless of the number of specific setae involved.

On extremely tiny specimens (less than 1.5 mm), a weak, single median propodeal carina is present but may be visible only at certain angles of view. In large specimens (more than 3.0 mm) the median carina varies from a single, distinct carina to an inverted V-shaped carina that reaches from the dorsellum to the nucha and sometimes (as in the case of the holotype) one or more forked carinae may be obscure.

Type material.—Holotype ♀, Brown Canyon, Kern Co., California, ex cell *Osmia marginata* Cresson, Frank Parker, (FP #2083E) (USNM); 89♀, 51♂ paratypes from the following localities (all collected by F. D. Parker and deposited in USNM, CNC, BMNH, USU): California: Imperial Co.: 2♀ Glamis, ex cell *Hoplitis palmarum* (FP #2320B). Kern Co., Sand Canyon (3 mi. W Brown): 4♀, ex cell *Ashmeadiella cubiceps* (FP #4188D); 15♂ ex cell *Ashmeadiella* sp. (FP #4183A); 5♀, 2♂ same data as holotype. Riverside Co.: 5♀ 18 mi. W Blythe, ex cell *Ashmeadiella* sp. (FP #2954A); Thousand Palms, 4♀, 2♂ ex cell of *Ashmeadiella rufipes* (FP #4532); 10♀, 6♂ ex cell of *Ashmeadiella bigeloviae* (FP #4531A); 6♀, 1♂ ex nest of *Ashmeadiella rufipes* (FP #4527); 10♀, 7♂ White Water, ex cell *Osmia marginata* (FP #2456B). San Bernardino Co.: 8♀, 1♂ Krammer Junction, ex cell *Ashmeadiella cubiceps* (FP #4369C); 4♀, 5♂ same data (FP #4333J). Yolo Co.: 6♀ Davis, ex cell *Megachile brevis* Say (FP #1384). Nevada: Churchill Co.: 5♀, 1♂ 12 mi. NE Stillwater, ex cell *Ashmeadiella gillettei* (FP

#3126B); Washoe Co.: 5♀, 3♂ Nixon, ex cell *Ancistrocerus* (FP #4015G); 5♀, 6♂ Patrick, ex cell *Hoplitis bullifacies* (FP #3665); 10♀, 2♂ Wadsworth, ex cell *Ashmeadiella rufipes* (FP #3584D).

Other material examined.—In addition to the type material, I have seen the following: Arizona (USNM unless specified otherwise): Gila Co.: 17♀, 9♂ 2.5 mi. E Verde River, bordering Hwy 87, em 29 March to 24 April 1963, Cazier, Mortenson; La Paz Co.: 10♀, 2♂ 2.8 mi. E Parker, coll. 9 May 1963, em. 26 May 1963, "green plug", Cazier, Mortenson; 9♀, 2♂ same data except em. 23 May, galls *Hilaria rigida*, "resin pobble" [? = pebble]. California: 8♀, 4♂ Imperial Co.: Glamis, coll. January 1964, F. Parker, ex *Leptochilus* sp. nests in old beetle borings in *Ephedra* stems (F. Parker per. comm.) (USU); Inyo Co.: 1♀ 15 km S Deep Springs, 24 May 1994, S. L. Heydon, sweeping *Encelia* (UCD); 1♀ same, except 13 km SE Deep Spring, off *Larrea* (UCD); 1♀ 14 km NW Darwin, 25 May 1994, S. L. Heydon (UCD). San Bernardino Co.: 4♀ 5 mi. N Barstow, 13 May 1979, R. M. Bohart (UCD); Utah: Emery Co.: 1♀ 6 km N Gilson Butte, 3–7 August 1997, M. & J. Wasbauer, pan trap (UCD); 1♀ same, except Wild Horse Creek, N Goblin Valley, 2–7 August 1997 (UCD).

Etymology.—This species is named in honor of the collector, Frank Parker.

Distribution.—This species is widespread in the western and southwestern United States (see Discussion section below).

Hosts.—All specimens were reared from Megachilidae and Vespidae (Eumeninae). Megachilid hosts were: *Ashmeadiella bigeloviae*, *A. cubiceps*, *A. gillettei*, *A. rufipes*, *Hoplitis bullifacies*, *H. palmarum*, *Megachile brevis*, *Osmia marginata*. Eumenine hosts were *Ancistrocerus* sp. and *Leptochilus* sp.

Although there is no specific insect host data on the specimens collected in Arizona by "Cazier and Mortenson", there are some indications as to what they were actually parasitizing. Label data states that

some were reared from "green plug" and some from galls with "resin pobble" [likely a misspelling of pebble] associated with *Hilaria rigida* (Thurb.) Benth. ex Scribn. (Poaceae). These galls are caused by *Cathililaria rigida* Zerova (Zerova 1999), which is not the actual host. Frank Parker (in litt.) says the following about these rearings: "I have collected nests from these same galls in the same area. They were made by *Ashmeadiella* spp., especially *A. gillettei* Titus (gravel and masticated leaf pulp) and *A. melillotti* Cockerell, the common green plugger! The resin nests are usually made by *A. cactorum* Cockerell, but species of *Proteriadodes* (now *Hoplitis*) do the same thing, using small pebbles stuck together with resin. All are common in this area. I have reared the same species from other galls and trap stems." It is obvious, then that the empty galls of *Cathililaria* were simply usurped by several genera of bee nest builders.

Biology.—Based on a subsample of 45 rearings by Frank Parker *Microdontomerus parkeri* is a gregarious parasitoid within individual bee cells. The number of individuals ranged from 2 to 33 per cell, with an average of about 8–9. For these rearings the total number of *M. parkeri* specimens was 229 females and 125 males for a sex ratio of 1.8 to 1. Ten of these rearings contained no males.

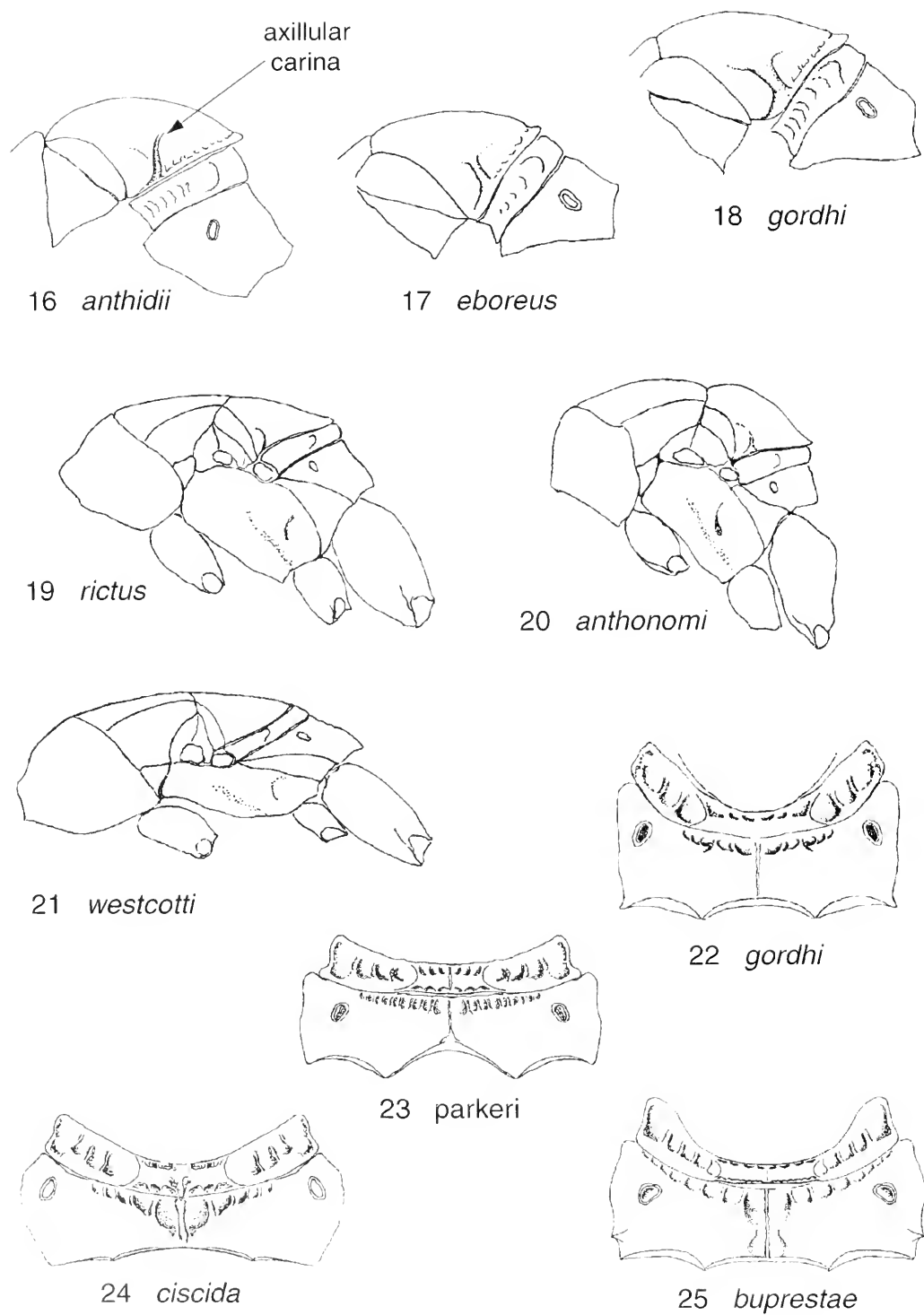
Discussion.—This species superficially resembles *M. anthonomi* but differs in wing setation as explained in couplet 9 of the key. *Microdontomerus parkeri* appears similar to *M. bicoloripes* based on body coloration and in reduced wing setation of the forewing admarginal area (Fig. 6). Coloration sometimes helps distinguish between the two: *M. parkeri* typically has the legs (especially femora, but never the coxae) shaded with black whereas *M. bicoloripes* typically has bright orange legs (sometimes including the coxae, as well). Larger specimens of *M. parkeri* sometimes have the legs entirely orange and smaller specimens of *M. bicoloripes* sometimes

have the femora and tibiae infused with black, so the character is not foolproof. *Microdontomerus parkeri* differs in having the speculum and basal cell open behind (Fig. 6) (closed in *M. bicoloripes*, Fig. 9) and in having the lateral ocellus slightly greater than the ocellocular distance (Fig. 39) (less than ocellocular distance in *M. bicoloripes*, Fig. 38).

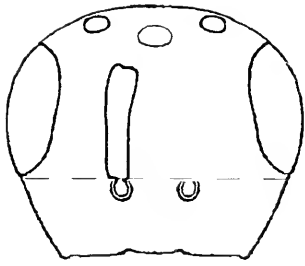
During my studies I examined a large number of specimens (over 2000, representing over 500 rearings, in the collection of USU) reared from stick trap nests set out by Frank Parker (Research Entomologist, retired; USDA Bee Biology and Systematics Laboratory, Utah State University, Logan). Unfortunately at the time I examined these specimens I believed only one species was present (*M. anthidii*), but as it turns out at least three species were present (*M. parkeri*, *M. enigma*, *M. anthidii*). I have not rechecked all 500 rearings, but based on a reexamined subsample of 355 specimens from 40 rearings, *M. parkeri* was the predominant parasitoid (86%), with *M. anthidii* and *M. enigma* each composing 7% of the total. The state and county records summarized next are almost surely all *M. parkeri* based on its abundance and the known distribution of *M. anthidii* (southern California) and *M. enigma* (Nevada). I did not include them in the above distribution section due to possible confusion: Arizona (Coconino, Yavapai, Maricopa, Yuma, Mohave, Gila, Cochise); California (Fresno, Inyo, Kern, Riverside, San Bernardino); Idaho (Butte, Owyhee); Nevada (Clark, Elko, Humboldt, Lyon, Washoe); New Mexico (Dona, Hidalgo, Luna, Sierra, Socorro, Valencia, Valencia); Utah (Box Elder, Cache, Duchesne, Grand, Juab, Millard, Rich, Washington).

***Microdontomerus rictus* Grissell,
new species
Figs. 19, 26, 45**

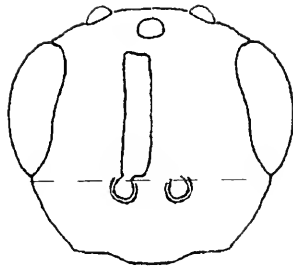
Holotype female.—Body length excluding ovipositor 2.5 mm, ovipositor 1.0 mm. Body black (without metallic sheen) ex-



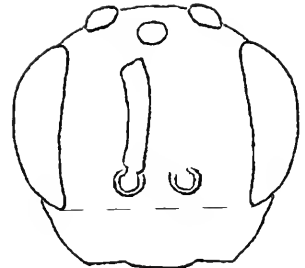
Figs. 16–25. *Microdontomerus* spp., metasoma. 16–18, Scutellum, metanotum, and propodeum, lateral view. 19–21, Entire metasoma, lateral view. 22–25, Metanotum and propodeum, dorsal view.



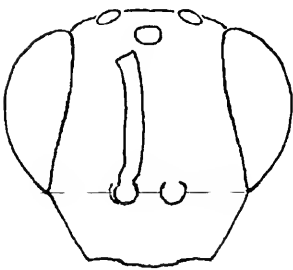
26 *rictus*



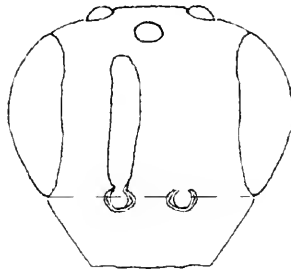
27 *buprestae*



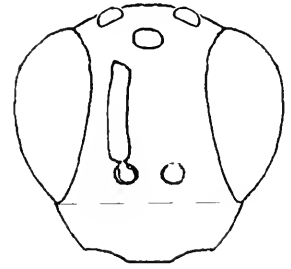
28 *parkeri*



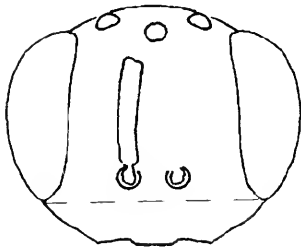
29 *secus*



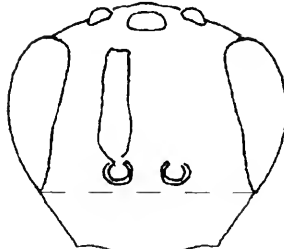
30 *ciscida*



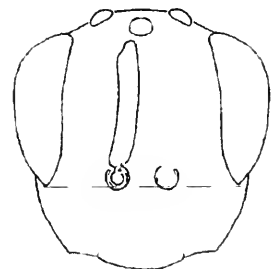
31 *anthidii*



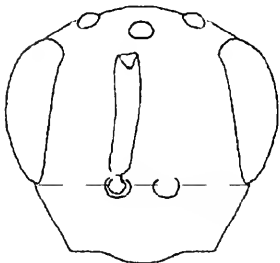
32 *hemileucae*



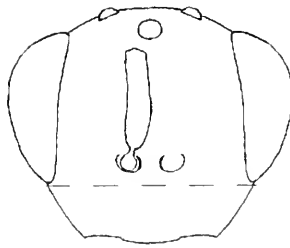
33 *enigma*



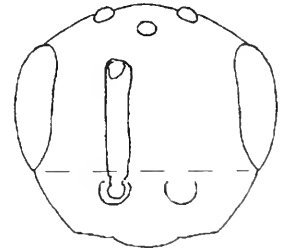
34 *darwini*



35 *mysticus*



36 *bicoloripes*



37 *westcotti*

Figs. 26–37. *Microdontomerus* spp., face showing proportions and position of torulus relative to eye (dashed line).

cept as follows: dark orange are: scape, all tibiae and tarsi; brown are: wing veins, femora. **Head:** Distance between eyes much greater than eye height (about $1.4\times$); clypeus (Fig. 26) recessed, not projecting beyond lateral corners of oral fossa; ratio of ocellocular distance: postocellar distance: lateral ocellus diameter $14:24:7$; dorsum of torulus at lower margin of eyes; toruli about 2 diameters apart; intermalar distance about $2\times$ malar distance; eye height about $1.5\times$ malar distance; antenna (Fig. 45) with pedicel laterally about $2\times$ as long as broad apically, anellus quadrate, as long as F1, funicle segments wider than long, flagellum slightly wider distally than proximally but essentially parallel-sided, scape not reaching median ocellus and separated from it by about an ocellus diameter. **Mesosoma:** Scutellum flat (Fig. 19), nearly in same plane as scutum, metanotum and propodeum not in same plane as apex of scutellum; posterior axillular carina reduced and narrow; dorsellum convex, polished, with obscure median carina and minute pits along dorsal and ventral margins; propodeum with several small pits along anterior margin (perpendicular carinae present), medially flattened, with indistinct carinae extending from dorsal margin and fading medially, nucha a narrow, arched carina, posterolateral corner of propodeum rounded, without distinct projecting denticle; spiracle greater than its own longest inner diameter from posterior margin of metanotum, median length of propodeum about $4\times$ longest inner spiracle diameter; forewing ratio PV:MV:SV:SMV as $10:18:5:36$, postmarginal vein about $0.5\times$ marginal vein, costal cell below with 1 to 2 complete anterior setal rows, upper surface without setae; basal setal line with several setae; cubital setal line with setae basally (i.e., basal cell closed), with partial bare areas paralleling either side, dorsal and ventral areas ending at about midpoint of marginal vein; basal cell with 1 or 2 setae; admarginal area not defined by posterior

line of setae and with 7 or 8 wide spaced setae above, parastigmal and basal areas bare; stigmal area bare. **Metasoma:** MT2 faintly emarginate at apico-median margin; other terga entire; ovipositor sheaths subequal to length of metasoma, $1.5\times$ as long as metatibia.

Male.—Unknown.

Variation.—Females vary in range from about 2.0 to 2.5 mm. The ovipositor is constant at about $1.5\times$ as long as the metatibia. It is difficult to assess wing setation due to the generally poor condition of the wings. Some wings appear to be nearly bare.

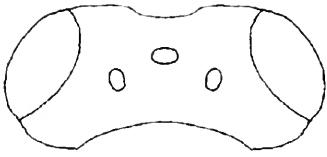
Type material.—Holotype ♀, 18 mi. SW Mt. [Mountain] Home, Elmore Co., Idaho, January 1958, W. F. Barr, "reared from larva from *Cylindrocopterus* boring in bud sage" (USNM); 3 ♀ paratypes, same data (USNM); 1 ♀ paratype, Fernley, Lyon Co., Nevada, 11 June 1974, R. M. Bohart (UCD).

Etymology.—From "*rictus*", Latin for "open mouth", in reference to the large malar opening.

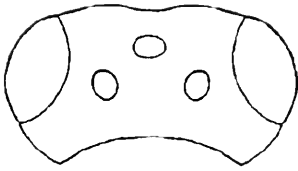
Distribution.—Known only from Elmore County, Idaho.

Host.—Reared from *Cylindrocopterus* sp. (Curculionidae) borings in bud sage (= *Artemisia spinescens* D. C. Eaton) (Asteraceae).

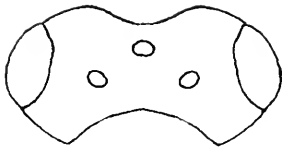
Discussion.—*Microdontomerus rictus* belongs to the group of species in which the scutellum is dorsally flattened and smooth (or at least less sculptured in contrast to the anterior of the scutum), the venter of the torulus is low on the face relative to the lower margin of the eye, and the ocellocular distance is greater than the longest lateral ocellus diameter. The species is unique in having a relatively wide head (Fig. 26) with the toruli about 2 diameters apart (1 diameter in all other species), the eyes about $1.5\times$ the malar distance (1.7 or greater in other species), and the distance between the eyes about $1.5\times$ the eye height (1.2 or less in other species).



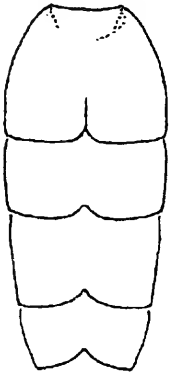
38 *bicoloripes*



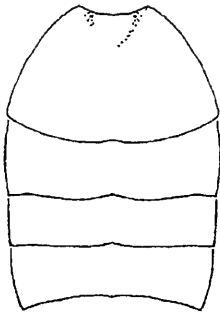
39 *parkeri*



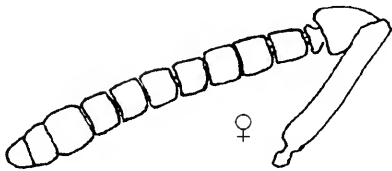
40 *westcotti*



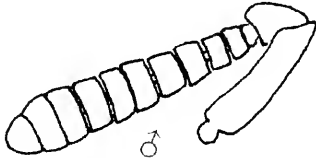
41 *buprestae*



42 *mysticus*

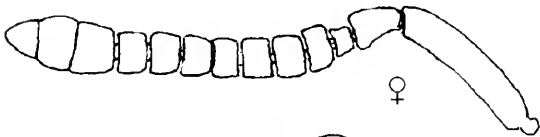


♀

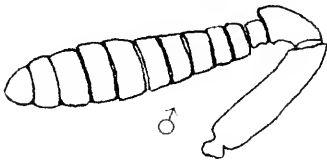


♂

43 *enigma*

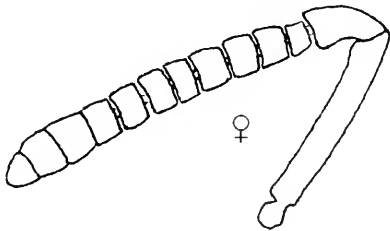


♀



♂

44 *westcotti*



♀

45 *rictus*

Figs. 38–45. *Microdontomerus* spp., 38–40, Head, dorsal view showing relative position of ocelli. 41–42, Metasomal terga (MT). 43–45, Antennae, lateral view.

Microdontomerus secus Grissell,
new species
Figs. 29, 53

Holotype female.—Body length excluding ovipositor 2.0 mm, ovipositor 0.5 mm. Body black (without metallic sheen) except yellow-orange are: scape, tibiae, and tarsi; wings weakly shaded brown below marginal vein, wing veins brown. **Head:**

Distance between eyes slightly less than eye height; clypeus (Fig. 29) level with lateral corners of oral fossa; ratio of ocellular distance: postocellar distance: lateral ocellus diameter 5:16:6; venter of torulus on line with venter of eyes; toruli about 1 diameter apart; intermalar distance about 1.5× malar distance; eye height about 2.0× malar distance; antenna (Fig. 53) with

pedicel laterally about $1.5\times$ as long as broad apically, anellus not elongate, shorter than F1, funicle segments wider than long, flagellum parallel-sided, club (Fig. 53, inset) appearing 4-segmented and with flat micropilose ventral area covering surface except base and lateral margins of first clavomere; scape nearly reaching median ocellus, separated from it by less than half an ocellus diameter. **Mesosoma:** Scutellum convex, not in same plane as scutum; metanotum and propodeum angled downward from plane of scutellum; posterior axillular carina short, straight, and slightly widened dorsally; dorsellum irregularly carinate with deep pits; propodeum covered with raised reticulation, with pits along anterior margin (perpendicular carinae present) becoming smaller towards outer margin, with strong median carinae extending from dorsal margin to nucha, nucha a narrow arched carina, posterolateral corner of propodeum rounded, without distinct projecting denticle; spiracle subequal to own longest inner diameter from posterior margin of metanotum, median length of propodeum about $3\times$ longest inner spiracle diameter; forewing ratio PV:MV:SV:SMV as 15:22:8:65, postmarginal vein about $0.6\times$ marginal vein, costal cell below with 1 to 2 complete anterior setal rows and nearly covered with setae except median crescent area, upper surface with anterior setal row in distal half; basal setal line complete; cubital setal line complete (i.e., basal cell closed), with partial bare areas paralleling both sides and ending at about midpoint of marginal vein; basal cell with complete setal row; admarginal area not defined by posterior line of setae and with dense setae above, parastigmal and basal areas bare; stigmal area setose. **Metasoma:** Terga entire, without median emarginations; ovipositor sheaths shorter than metasoma, $0.7\times$ as long as metatibia.

Male.—Unknown.

Variation.—The paratype specimen exhibits a more notable infumation of the

wings, and the micropilose ventral area of the clava is slightly concave rather than flat.

Type material.—Holotype ♀, 45 km NW Santa Barbara, Santa Barbara Co., California, Sedgewick Reserve, 25 June 1997, E & M. Schlinger, Malaise trap (USNM); 1♀ paratype, Kern River Canyon, 4–7 mi. E Johnsondale, Tulare Co., California, 22 May 1991, N. J. Smith (UCD).

Etymology.—From “*secus*”, Latin for “different”, in reference to the micropilar areas on the ventral aspect of the club, which so far is unique to this species.

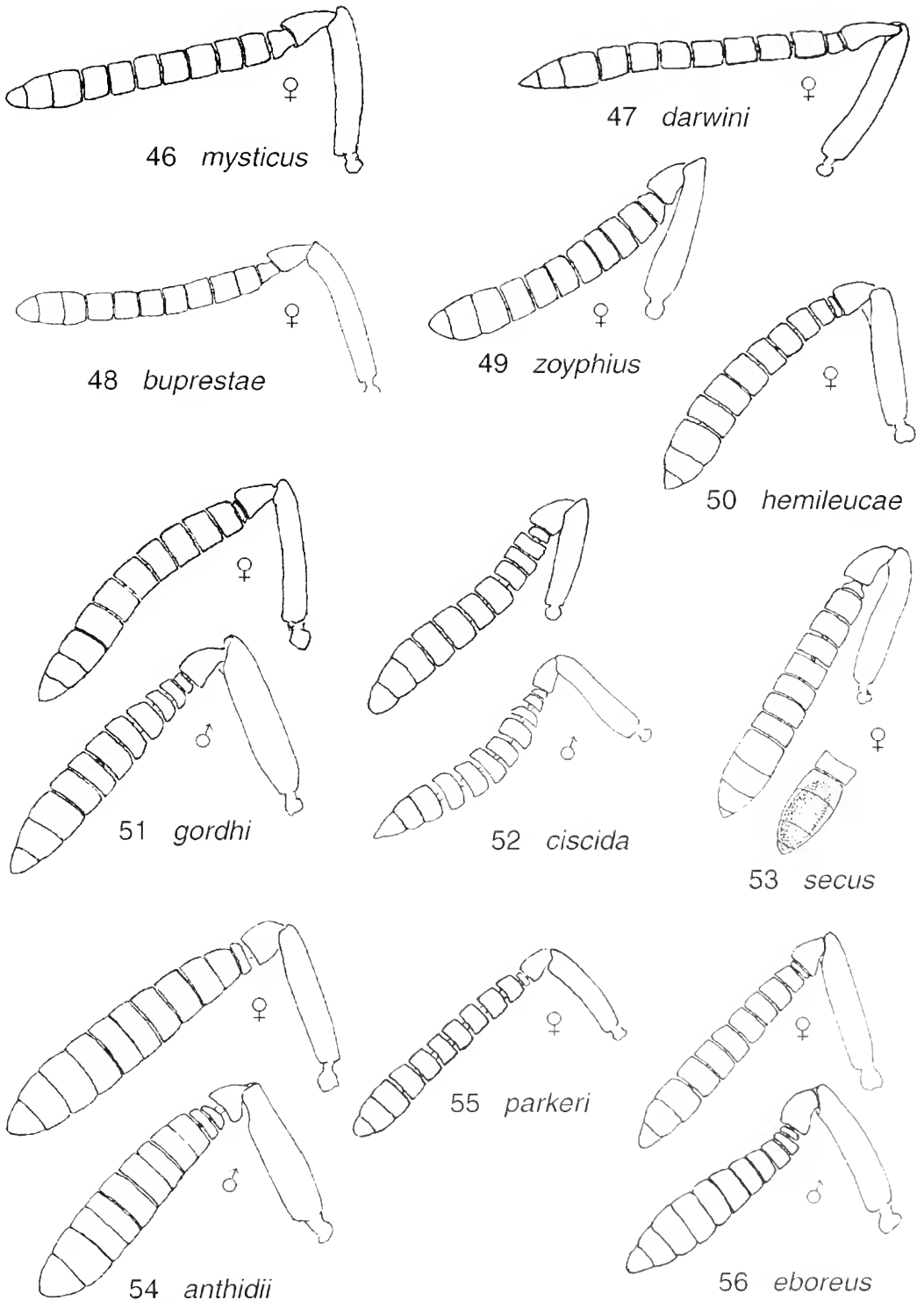
Host.—Unknown.

Discussion.—This is the only species known so far with the ventral area of the club (except basal half of C1) covered with micropilosity (Fig. 53, inset). The area is flat in the holotype and concave in the paratype (likely an artifact of collapse). The species also appears to have a distinctly 4-segmented club as a result of an annulation just before its apex. This annulation is either absent or not easily seen in other species. The extremely short ovipositor, which is $0.7\times$ the length of the metatibia, and the slightly shaded wings also help distinguish this species.

Microdontomerus westcotti Grissell,
new species

Figs. 21, 37, 40, 44

Holotype female.—Body length excluding ovipositor 2.0 mm, ovipositor 0.8 mm. Body brown (without metallic sheen) except as follows: dark brownish yellow are: scape, tibiae (except apex white); tarsi white. **Head:** Distance between eyes slightly greater than eye height ($1.2\times$); clypeus (Fig. 37) projecting beyond lateral corners of oral fossa; ratio of ocellocular distance: postocellar distance: lateral ocellus diameter 12:20:5 (Fig. 40); dorsum of torulus at venter of eyes; toruli about 1 diameter apart; intermalar distance about $1.7\times$ malar distance; eye height about $1.7\times$ malar distance; antenna (Fig. 44♀) with pedicel laterally about $2\times$ as long as



Figs. 46–56. *Microdontomerus* spp., antennae, lateral view. 53, Inset, venter of club.

broad apically, anellus quadrate, shorter than F1, funicle segments wider than long, flagellum slightly wider distally than proximally but essentially parallel-sided, scape not reaching median ocellus, separated from it by about an ocellus diameter.

Mesosoma: Scutellum flat (Fig. 21), nearly in same plane as scutum, metanotum and propodeum flat and in same plane as apex of scutellum; posterior axillular carina reduced and narrow; dorsellum flat, with slight median groove and no pits; propodeum subhorizontal (Fig. 21), with several small pits along anterior margin (perpendicular carinae present), medially flattened, with distinct carinae extending from dorsal margin to nucha, nucha a narrow, arched carina, posterolateral corner of propodeum rounded, without distinct projecting denticle; spiracle greater than own longest inner diameter from posterior margin of metanotum, median length of propodeum about $3\times$ longest inner spiracle diameter; forewing ratio PV:MV:SV:SMV as 2:4:1:13, postmarginal vein about $0.5\times$ marginal vein, costal cell below with 1 to 2 complete anterior setal rows, upper surface without setae; basal setal line complete; cubital setal line with setae basally (i.e., basal cell closed), with partial bare areas paralleling either side, dorsal and ventral areas ending at about midpoint of marginal vein; basal cell with complete setal row; admarginal area not defined by posterior line of setae and with dense setae above, parastigmal and basal areas bare; stigmal area bare. Metasoma: MT2-3 slightly emarginate at apico-median margin; other terga entire; ovipositor sheaths shorter than meso- plus metasoma, $1.4\times$ as long as metatibia.

Male.—Body length 2.0 mm. Color, sculpture, and other characters about as for female except: eye height about $3\times$ malar distance; scape ventrally flat and polished; antenna spindle-shaped (Fig. 43♂), basal flagellomeres reduced, much wider than long (F1-2 "anellus-like", but with multiporous plate sensilla).

Variation.—Females vary from about 1.6 to 2.6 mm. The specimens reared from *Baris* are black (instead of brown) with the scape mostly black. The single female from Riverside has a very slight purplish metallic sheen on the head, as do some of the paratypes, but this is difficult to see.

Type material.—Holotype ♀, 4 mi. N Red Bluff, Tehama Co., California, 4 April 1975, R. L. Westcott, ex *Nanularia californica* pupal cell in crown of *Eriogonum nudum* (USNM); 10♀, 1♂ paratypes all same data (USNM); 5♀, California, Yolo Co., 4 mi. NE Woodland (sewer pond), em. February 1971, J. E. Lauck, ex *Baris digitata* [lapsus for *dilatata*] in root of *Xanthium* sp. (USNM, UCD).

Additional material examined.—1♀, Riverside, Riverside Co., California, 17 July 1978, J. C. Hall (UCR).

Etymology.—This species is named for Rick Westcott, the collector, who has discovered several wonderful new species of *Microdontomerus* while studying the lesser beetles he somehow finds interesting.

Distribution.—*Microdontomerus westcottii* is known from Tehama and Yolo counties in northern California and Riverside County in southern California.

Host.—This species was reared from *Nanularia californica* (Burprestidae) in the crown of *Eriogonum nudum* (Douglas ex Benth) (Polygonaceae) and from *Baris dilatata* (Curculionidae) infesting roots of *Xanthium* sp. (Asteraceae).

Discussion.—*Microdontomerus westcottii* belongs to a group of species in which the scutellum is dorsally flattened and smooth (or at least less sculptured in contrast to the anterior of the scutum), the venter of the torulus is low on the face relative to the lower margin of the eye, and the ocellular distance is greater than the longest lateral ocellus diameter. This is one of the smallest, least robust species in the genus, having scarcely any distinct sculpturing or propodeal carinae. It keys out with *M. zoyphius*, from which it can be separated by characters given in the key.

The specimen cited above from Riverside appears morphologically identical to *M. westcotti*, but its distribution is far removed to the south of the type localities. It also has some metallic reflection, suggesting that it might not be *M. westcotti*, which is why I did not include it in the type series.

Microdontomerus zoyphius Grissell,
new species

Figs. 4, 49

Holotype female.—Body length excluding ovipositor 2.8 mm, ovipositor 0.7 mm. Body black (without metallic sheen) except orange are: scape, tibiae, and tarsi; wing veins brown. **Head**: Distance between eyes subequal to eye height; clypeus barely projecting beyond lateral corners of oral fossa; ratio of ocellular distance: postocellar distance: lateral ocellus diameter 6:12:5; dorsum of torulus about half own diameter lower than eyes; toruli slightly greater than own diameter apart; intermalar distance about $2\times$ malar distance; eye height about $2\times$ malar distance; antenna (Fig. 49) with pedicel laterally about $2\times$ as long as broad apically, anellus transverse, much shorter than F1, funicle segments wider than long, flagellum parallel-sided, scape not reaching median ocellus, separated from it by about an ocellus diameter. **Mesosoma**: Scutellum flat, nearly in same plane as scutum, metanotum and propodeum flat and in same plane, but not in same plane as apex of scutellum; posterior axillular carina reduced and narrow; dorsellum convex, smooth, without median carina, dorsal margin with small pits; propodeum subhorizontal, with several small pits along anterior margin (perpendicular carinae present), with distinct median carina subtended by barely perceptible depressions on either side, carina extends from dorsal margin to nucha, which is narrow, arched carina, posterolateral corner of propodeum rounded, without distinct projecting denticle; spiracle slightly less than own

longest inner diameter from posterior margin of metanotum, median length of propodeum about $3.5\times$ longest inner spiracle diameter; forewing ratio PV:MV:SV:SMV as 3:6:2:14, postmarginal vein about $0.5\times$ marginal vein, costal cell below with 1 to 2 complete anterior setal rows and nearly covered with setae, upper surface without setae; basal setal line complete; cubital setal line with setae basally (i.e., basal cell closed), with partial bare areas paralleling ventral side, ending at about midpoint of marginal vein; basal cell with complete setal row; admarginal area not defined by posterior line of setae and with dense setae above, parastigmal and basal areas bare; stigmal area asetose. **Metasoma**: MT2 slightly emarginate at apico-median margin, other terga without emarginations; ovipositor sheaths shorter than metasoma, $1.0\times$ as long as metatibia.

Male.—Unknown.

Variation.—The two females show little variation.

Type material.—Holotype ♀, Texas, Brewster Co., Big Bend National Park, Buttril Spring, 4–5 October 1991, R. Wharton (TAMU); 1♀ paratype same data (USNM).

Etymology.—From “*zoyphion*”, Greek for “little animal”.

Distribution.—Known only from Texas.

Host.—Given the similar appearance and flattened habitus of this species relative to *M. westcotti* and *M. buprestae*, which attack buprestids, I suspect that *M. zoyphius* most likely attacks beetles in this family as well.

Discussion.—*Microdontomerus zoyphius* belongs to a group of species in which the scutellum is dorsally flattened and smooth (or at least less sculptured in contrast to the anterior of the scutum), the venter of the torulus is low on the face relative to the lower margin of the eye, and the ocellular distance is greater than the longest lateral ocellus diameter. Phenotypically this species is a bit more like *M. ciscida* and *M. mysticus* relative to the propodeum

than to *M. westcotti* with which it keys out. The former two species have very distinct, strongly indicated depressions, pits, and carinae surrounding the median propodeal carina, whereas *M. zoyphius* has barely distinguishable shallow, reticulate areas on either side of the median carina. *Microdontomerus westcotti* has an essentially smooth propodeum and differs from *M. zoyphius* as indicated in the key.

HOST-PARASITOID LIST
(alphabetic)

COLEOPTERA

Anthribidae

Brachytarsus sp. see *Trigonorhinus* sp.
Trigonorhinus sp.: *Microdontomerus anthonomi*

Burprestidae

Chrysobothris sp.: *Microdontomerus burprestae*
? *Chrysobothris* sp.: *Microdontomerus mysticus*
Nanularia californica (Horn): *Microdontomerus westcotti*

Cerambycidae

Crossidius hirtipes LeConte: *Microdontomerus mysticus*

Chrysomelidae (Bruchinae):

Acanthoscelides aureolus (Horn): *Microdontomerus anthonomi*
Acanthoscelides compressicornis (Schaeffer): *Microdontomerus anthonomi*
Acanthoscelides derifieldi (Johnson): *Microdontomerus anthonomi*
Acanthoscelides desmanthi (Johnson): *Microdontomerus anthonomi*
Acanthoscelides horni (Pic): *Microdontomerus anthonomi*
Acanthoscelides mixtus (Horn): *Microdontomerus anthonomi*
Acanthoscelides pullus (Fall): *Microdontomerus anthonomi*
Bruchus brachialis Fahraeus: *Microdontomerus anthonomi*
Bruchus pisorum (L.): *Microdontomerus anthonomi*
Sennius morosus (Sharp): *Microdontomerus anthonomi*

Stator limbatus (Horn): *Microdontomerus anthonomi*

Stator pruininus (Horn): *Microdontomerus anthonomi*

Curculionidae

Anthonomus grandis Boheman: *Microdontomerus anthonomi*
Bangasternus orientalis (Capiomont): *Microdontomerus anthonomi*
Baris dilatata Casey: *Microdontomerus westcotti*
Cylindrocopterus sp.: *Microdontomerus rictus*
Lixus parvus LeConte: *Microdontomerus ciscida*
Microlarinus lareynii (Jaquelin du Val): *Microdontomerus anthonomi*
Rhinocyllus conicus Froelich: *Microdontomerus anthonomi*

DIPTERA

Tephritidae

Urophora affinis Frauenfeld: *Microdontomerus anthonomi*

Tachinidae

Deopalpus contiguus Reinhard [via *Eucaterva variaria*]: *Microdontomerus eboreus*
Exorista mella (Walker): *Microdontomerus fumipennis*
? tachinid [via *Hemileuca magnifica*]: *Microdontomerus fumipennis*

HETEROPTERA

Pentatomidae

eggs: *Microdontomerus hemileuca*

HYMENOPTERA

Braconidae

Aleiodes sp. [via *Sagenosoma elsa* larva]: *Microdontomerus braconivorus*
? *Aleiodes malacosomatos* (Mason) [via *Malacosoma distria* larva]: *Microdontomerus fumipennis*
Bracon mellitor Say: *Microdontomerus anthonomi*

Cynipidae

Antistrophus chrysothamni Beutenmüller: *Microdontomerus bicoloripes*

Antistrophus lygodesmiaepisum Walsh:
Microdontomerus bicoloripes

Eupelmidae

?*Anastatus semiflavus* [via *Hemileuca olivae* egg] Gahan: *Microdontomerus hemileucae*

Ichneumonidae

ichneumonid [via "tussock moth"]: *Microdontomerus fumipennis*

ichneumonid pupa [via *Agapema galbina anona*]: *Microdontomerus fumipennis*

Megachilidae

Anthidium consimile see *Dianthidium pudicum consimile*

Ashmeadiella bigeloviae (Cockerell): *Microdontomerus parkeri*

Ashmeadiella cubiceps (Cresson): *Microdontomerus parkeri*

Ashmeadiella gillettei Titus: *Microdontomerus parkeri*

Ashmeadiella rufipes Titus: *Microdontomerus parkeri*

Dianthidium pudicum consimile (Ashmead): *Microdontomerus anthidii*

Dianthidium sp.: *Microdontomerus anthidii*

Hoplitis bullifacies Michener: *Microdontomerus enigma*, *Microdontomerus parkeri*

Hoplitis palmarum (Cockerell): *Microdontomerus parkeri*

Megachile brevis Say: *Microdontomerus parkeri*

Megachile montivaga Cresson: *Microdontomerus apianus*

Osmia marginata Michener: *Microdontomerus parkeri*

Vespidae

Ancistrocerus sp.: *Microdontomerus parkeri*

Leptochilus sp.: *Microdontomerus anthidii*,
Microdontomerus parkeri

LEPIDOPTERA

Coleophoridae

Coleophora malivorella Riley: *Microdontomerus anthonomi*

Coleophora parthenica Meyrick: *Microdontomerus anthonomi*

Geometridae

Eucaterva variaria Grote [ex *Deopalpus configuus* in host]: *Microdontomerus eboreus*,
Microdontomerus gordii

Lasiocampidae

Malacosoma californicum fragile (Stretch):
Microdontomerus fumipennis

Malacosoma dissτρια (Hübner) [? ex *Aleiodes malacosomatos* in larval host mummy]:
Microdontomerus fumipennis

Malacosoma fragile see *Malacosoma californicum fragile*

Malacosoma incurvum (Hy. Edwards):
Microdontomerus fumipennis

Lymantriidae

Orgyia pseudotsugata (McDunnough):
Microdontomerus fumipennis

Orgyia vetusta (Boisduval): *Microdontomerus fumipennis*

Saturniidae

Agapema galbina anona (Ottolengui) [ex ichneumonid pupa]: *Microdontomerus fumipennis*

Hemileuca magnifica (Rotger) (or? hyperparasite in tachinid): *Microdontomerus fumipennis*

Hemileuca olivae Cockerell: *Microdontomerus fumipennis*; *Microdontomerus hemileucae*

Sphingidae

Sagenosoma elsa (Strecker) [ex *Aleiodes* in larva]: *Microdontomerus braconivorus*

Tortricidae

Ancylis comptana (Froelich): *Microdontomerus anthonomi*

Archips argyrospila (Walker): *Microdontomerus fumipennis*

Choristoneura rosaceana (Harris): *Microdontomerus fumipennis*

Rhyacionia zonana (Kearfott): *Microdontomerus fumipennis*

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NOTE

***Leucospis dorsigera* Fabricius (Hymenoptera, Leucospidae) as a Hyperparasitoid of Cerambycidae (Coleoptera) through Xoridinae (Hymenoptera: Ichneumonidae) in Iran**

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The genus *Leucospis* (Chalcidoidea: Leucospidae) is distinct among the Chalcidoidea both morphologically and biologically. The species are usually robust, patterned vespid-like with yellow or red stripes on a black ground color. The hind femora are swollen and toothed beneath as in the Chalcididae but the fore wings are folded longitudinally and the ovipositor is turned up over the abdomen (Bouček 1974, Grissell and Schauff 1997).

Determination of host associations for parasitic wasps is fraught with difficulties. They are particularly problematic when it comes to concealed hosts, especially those living in deep or potentially complex situations where more than one species may be involved (Noyes 1994). In this paper, we report a new host relationship for *Leucospis dorsigera* Fabricius, 1775 in Iran.

During the study of the natural enemies of the Rosaceae branch borer, *Osphranteria coerulescens* Redtenbacher, 1850 (Coleoptera: Cerambycidae) on apricot trees in Abarkouh region of Yazd province, Iran, branches infested with borer larvae were hatched in plastic cages. Several parasitoid species emerged from the samples: *Eurytoma* sp. (Hymenoptera: Eurytomidae), *Xorides corcyrensis* (Kriechbaumer, 1894) (Hymenoptera: Ichneumonidae: Xoridi-

nae) and also five specimens of *Leucospis dorsigera* (Fig. 1). At first, we assumed that *L. dorsigera* emerged from a wasp or a bee nesting in holes in the wood, but we could not find any of its known hosts. For this species, there are records from Apidae (Hymenoptera) and Bostrychidae (Coleoptera) (Noyes 2004), but the latter host records were considered doubtful by Baur and Amiet (2000). To discover the possible host of *L. dorsigera* some infested branches were opened by the senior authors. Finally, five *Xorides* cocoons (Fig. 2) contained remnants of a *X. corcyrensis* larva together with a single ectoparasitoid larva which pupated after a few days and yielded *L. dorsigera*.

This is the first recorded instance of a species of *Leucospis* developing as a hyperparasitoid. Host records have been reported only for 33 (Grissell and Schauff 1997) of the 121 known species, all of them develop as primary parasitoids of aculeate Hymenoptera. Their hosts are mainly solitary bees, less frequently solitary wasps, e.g. Vespidae and Sphecidae nesting in a similar way as the bees. Except for one gregarious species (Grissell and Cameron 2002), all *Leucospis* develop—as far as is known—as solitary parasitoids. Occasionally parasitic bees have also been recorded

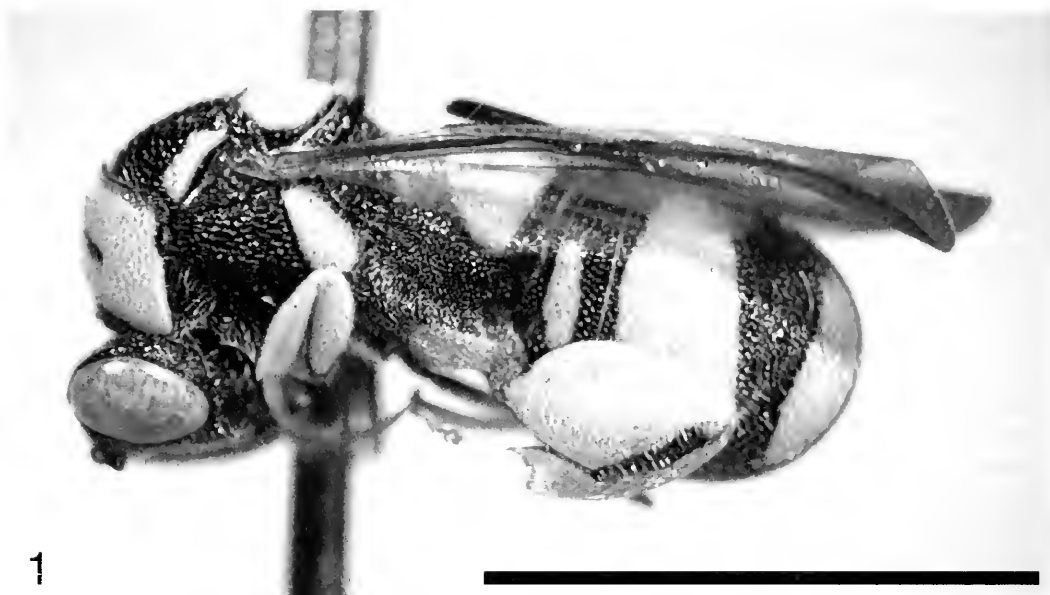


Fig. 1. Female of *Leucospis dorsigera*, emerged from larvae of *Xorides corcyrensis* (scale 0.5 cm).

as hosts for certain Palearctic species (Bouček 1974), but such records were considered doubtful by Baur and Amiet (2000).

L. dorsigera is a rather variable and widely distributed species that occurs from Eastern Russia through Western Europe to North Africa (Bouček 1974, Noyes 2004). The five specimens obtained from the *Xorides* cocoons show rather extensive yellow markings (Fig. 1). Furthermore, the gaster of the female is relatively short and in lateral view broadly rounded at the apex. Its ovipositor sheaths just reach to

the base of the gaster. The ratio of ovipositor sheath to hind femur length is only 1.5, which lies slightly outside the range of 1.53–1.92 given by Baur and Amiet (2000) for European specimens. In all other characters, especially the shape of the clypeus and the first gastral tergite (compare Baur and Amiet 2000: 367, figures 5a and 5b), the specimens fit very nicely the diagnosis of *L. dorsigera* provided by Bouček (1974) and Baur and Amiet (2000). According to Bouček (1974), pale coloration and a relatively short gaster were also ob-



Fig. 2. Opened cocoon of *Xorides corcyrensis* containing a pupae of *L. dorsigera* together with frass and the remnants of the *Xorides* larva (scale 1 cm).

served in other specimens collected in southern parts of the distribution area of this species.

Specimens of *L. dorsigera* are deposited in the Natural History Museum, Bern, Switzerland (1 female) and in the Dept. of Plant Protection, Shiraz Islamic Azad University, Shiraz, Iran (1 female, 3 males); specimens of *X. corcyrensis* (3 females, 2 males; 3 cocoons) and of *O. coerulea* (6 specimens) are deposited in the Dept. of Plant Protection, College of Agriculture, Tehran University, Karaj, Iran.

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The North American Invasion of the Giant Resin Bee (Hymenoptera: Megachilidae)

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Abstract.—The giant resin bee, *Megachile sculpturalis* Smith (Megachilidae: Megachilinae), is a species originally of Asia recently adventive in North America. This large and conspicuous species was first recorded at a few localities in the mid-Atlantic states of the United States, but is now found from southeastern Canada (Ontario) to Georgia, and as far west as western Pennsylvania and northwestern Alabama. Known occurrences of this species in its native distributional areas were used to generate an ecological niche model for the species, which can be used to anticipate the geographic potential for species in novel landscapes. The niche model was tested on the native range of the species for robustness in predicting independent suites of occurrence points. The niche model was then used to predict the potential distribution of *M. sculpturalis* in North America—our results indicate that this species has the potential eventually to occupy the entire eastern half of the continent, as far west as the Great Plains. The model also predicts that the species would find appropriate conditions along the Pacific Coast, in Mexico, and in the West Indies. Impacts of *M. sculpturalis* on native *Megachile* species are entirely unknown.

As the most significant and efficient pollinators of flowering plants, bees are critical for many aspects of the diversity and stability of both natural and agricultural ecosystems; in addition, honey bees have long been appreciated for their products (e.g., honey and wax; Michener 2000). These beneficial features make it difficult to think of bees as threats when introduced into areas outside their native ranges, despite the widely known negative effect of exotic species in general (Goulson 2003, Lawton and Brown 1986, Williamson 1999, NAS 2002, Perrings *et al.* 2002).

Several bee species have been introduced into novel regions by man, either deliberately or not. The most famous example is the western honey bee *Apis mel-*

lifera Linnaeus native to Africa, Europe, the Middle East, and northwestern Asia (Ruttner 1988), now globally distributed as human colonists have transported bee colonies. A famous episode in the presence of honey bees in the Americas was the experimental introduction in 1957 of the African *A. mellifera scutellata* Lepeletier de Saint Fargeau ("Africanized" honey bees) into Brazil, and the later establishment of feral populations throughout South and Central America, reaching the southern United States (Kerr 1957, 1967, Michener 1975, Taylor 1977, Sheppard and Smith 2000). Goulson (2003) mentioned other bee introductions carried out to improve pollination, among the most significant, species of the genera *Bombus*, *Me-*

gachile, *Osmia* and *Nomia*. Ascher (2001) mentioned the presence of 17 adventive bee species in North America, providing taxonomic, geographic and biological information for *Hylaeus* (*Spatulariella*) *hyalinatus* Smith, and occurrence notes for *Anthidium* (*Anthidium*) *manicatum* (Linnaeus), *A.* (*Proanthidium*) *oblongatum* (Illiger), *Hoplitis* (*Hoplitis*) *anthocopoides* (Schenck), *Chelostoma* (*Gyrodromella*) *rapunculi* (Lepeletier de Saint Fargeau)¹, *C.* (*Foveosmia*) *campanularum* (Kirby), and (our subject herein) *Megachile* (*Callomegachile*) *sculpturalis* Smith.

The giant resin bee, *M. sculpturalis*, is a robust bee widely distributed in eastern Asia (China, Japan, Taiwan, and Korea). The species is easily differentiated from native North American *Megachile* by its elongate (14–19 mm in males, 22–27 mm in females) parallel-sided body, black head, and dark mesosoma with fulvous setae (Mangum and Brooks 1997) (Fig. 1). It nests preferentially in shady places, a minimum of 0.5 m above the ground, in a variety of cavities, e.g., dry, hollow horizontal stems (bamboo in its native range), and empty burrows made by other hymenopterans (Iwata 1933, Okada 1995), including abandoned wood burrows of carpenter bees (Piel 1933). This latter behavior has already been documented in North American populations (Mangum and Brooks 1997). Brood cells are made of resin from conifers (Iwata 1933) and maple gum (Piel 1933), from which the name “giant resin bee” derives (Batra 1998). In Japan, its period of adult activity is from late June through September (Iwata 1933), coinciding with the blooming of kudzu [*Pueraria lobata* (Willdenow) Ohwi (Leguminosae)], its principal source of pollen (Batra 1998), although it is known to be

polylectic (Mangum and Brooks 1997). Combining the records reported by Batra (1998), Ascher (2001), and Mangum and Sumner (2003), in North America, *M. sculpturalis* has been recorded foraging on flowers of at least 16 plants of 12 families, the most commonly visited being everlasting pea, *Lathyrus latifolius* Linnaeus (Leguminosae); Japanese pagoda, *Sophora japonica* Linnaeus (Leguminosae); privet, *Ligustrum lucidum* W. T. Aiton (Oleaceae); and golden-rain tree, *Koelreuteria paniculata* Laxmann (Sapindaceae), the first native to Europe and the remainder to Asia. Female *M. sculpturalis* leave a trace of their foraging activity on flowers of everlasting pea and Japanese pagoda by puncturing the standard petal (Mangum and Sumner 2003).

In the last decade, *M. sculpturalis* has appeared in eastern North America, with populations established and spreading from their initial areas of appearance (probably near Baltimore, accidentally introduced, via cargo from Japan or China; Batra 1998, Mangum and Brooks 1997). *Megachile sculpturalis* was first collected in North America in 1994 on the campus of North Carolina State University, and by 1996 was widespread in North Carolina (Mangum and Brooks 1997), also reaching Delaware (Mangum and Sumner 2003). It has since spread over much of eastern North America, with records as far west as Athens, Limestone Co., Alabama, as far south as Auburn, Lee Co., Alabama (Kondo *et al.* 2000), and as far north as Onondaga Co., New York (Ascher 2001), and Ontario, Canada (Mangum and Sumner 2003). Records also exist from Georgia, South Carolina, Virginia, Maryland, Pennsylvania, West Virginia, Ohio, Washington D.C., Tennessee, and Connecticut (Mangum and Sumner 2003). Batra (1998) predicted, based on its Asian range, that *M. sculpturalis* would come to inhabit the humid, subtropical to temperate climates of the southeastern and mid-Atlantic Unit-

¹ This species has often been referred to by the older, but preoccupied, name of *C. fuliginosum* (Panzer) (a junior primary homonym in *Apis*), which was replaced by *C. nigricornis* (Nylander), but this itself is a synonym of *C. rapunculi*.

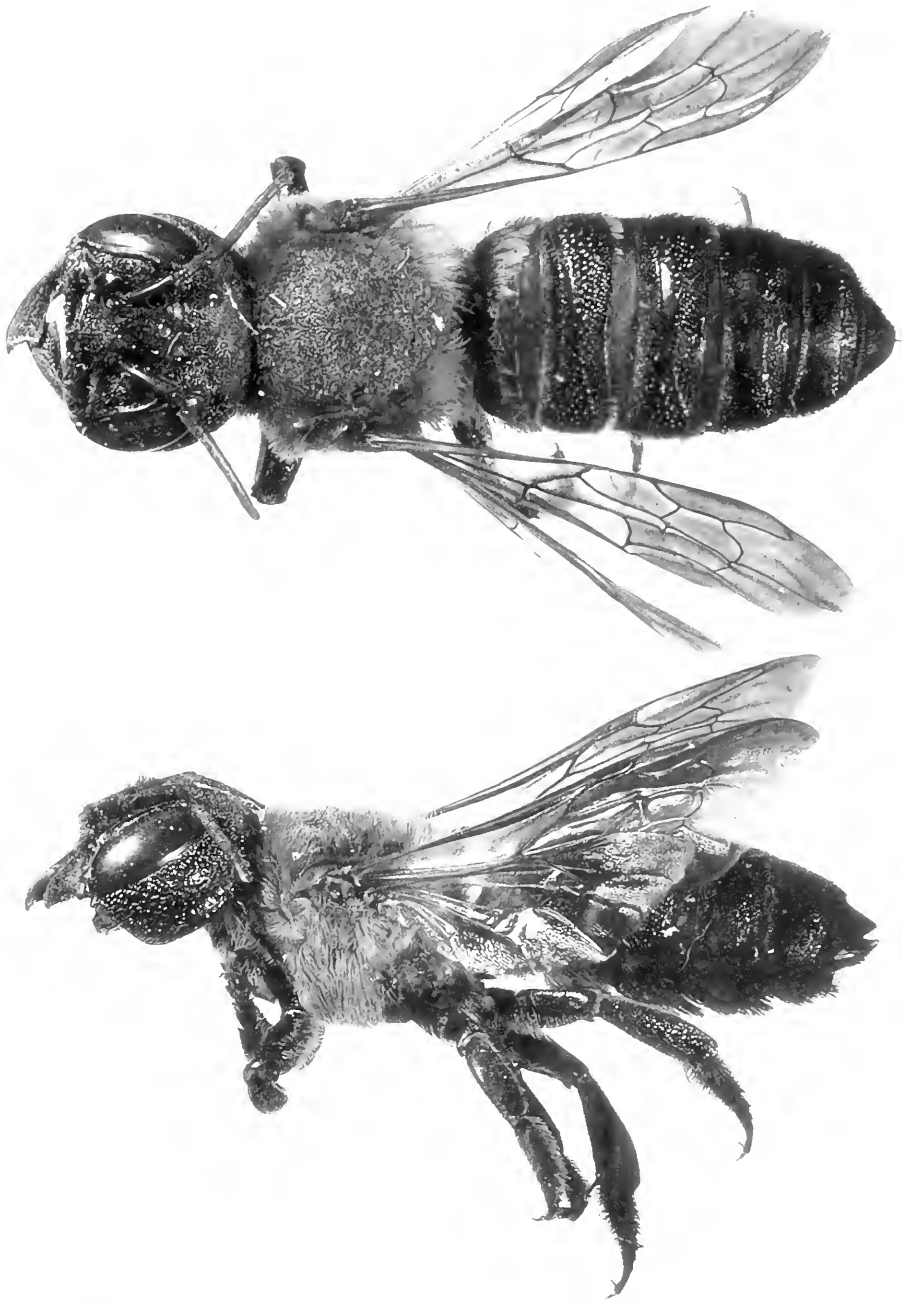


Fig. 1. *Megachile sculpturalis* Smith, female from Japan, above dorsal habitus, below lateral habitus.

ed States, from eastern Texas and Florida, north to southern New England.

Herein we have applied methods of ecological niche modeling. Extensive previous studies have indicated that native-

range ecological characteristics provide excellent predictivity regarding invaded-range ecological and geographic potential of species (Scott and Panetta 1993, Sutherland *et al.* 1999, Skov 2000, Zalba *et al.* 2000,

Peterson *et al.* 2003). Although this approach does not provide comprehensive predictions of geographic range because of other complicating factors (Peterson *et al.* 2003), the resulting predictions nevertheless offer an excellent summary of species' invasive potential. As such, we use this technique to predict the potential extent of *M. sculpturalis*' invasive range in North America.

METHODS

Input data.—Collections with specimens of *M. sculpturalis* were studied to obtain native-range occurrence data suitable for retrospective georeferencing. Specimen data were taken from the Snow Entomological Collection, Division of Entomology, University of Kansas Natural History Museum, Lawrence, KS, USA; Kyushu University, Japan; Institute of Zoology, Chinese Academy of Sciences, People's Republic of China; and the Natural History Museum, London, UK; as well as data from Huan-li Xu personal collection (People's Republic of China). Occurrences of the species on its invaded range in North America were gathered from the Snow Entomological Collection, University of Kansas Natural History Museum, Lawrence, KS, USA, and from recent published reports (Mangum and Brooks 1997, Batra 1998, Kondo *et al.* 2000, Ascher 2001, Mangum and Sumner 2003).

To summarize ecological variation across the native and introduced geographic distributions of the species, we used 15 raster grid data sets ('coverages'). These coverages summarized aspects of topography (elevation, topographic index, slope, and aspect, from the US Geological Survey's Hydro-1K data set, native resolution 1×1 km: <http://edcdaac.usgs.gov/gtopo30/hydro/>) and climate (annual means of diurnal temperature range; frost days; precipitation; maximum, minimum and mean monthly temperatures; solar radiation; wet days; and vapor pressure; for 1960–1990 from the Intergovern-

mental Panel on Climate Change, native resolution 50×50 km: <http://www.ipcc.ch/>). To minimize conflicts in scale between topographic and climatic data, we conducted analyses at an intermediate resolution (10×10 km).

Ecological niche modeling.—Ecological niches are herein defined as the set of conditions under which a species is able to maintain populations without immigration (Grinnell 1917, 1924). Our approach consisted of three steps. (1) Model ecological niche requirements of the species based on known occurrences in the native distribution area of the species. (2) Test the accuracy of the native-range predictions based on spatially structured subsets of the available information. (3) Project the niche model onto North America to identify areas predicted to be susceptible to invasion.

The software tool used for niche modeling was the Genetic Algorithm for Rule-set Prediction (GARP) (Stockwell and Noble 1992, Stockwell and Peters 1999). GARP uses an evolutionary-computing approach to carry out a flexible and powerful search for non-random associations between environmental variables and known occurrences of species, as contrasted with the environmental characteristics of the overall study area.

Specifically, available occurrence points are resampled with replacement to create a population of 1250 presence points; an equivalent number of points is resampled from the population of grid squares ('pixels') from which the species has not been recorded. These 2500 points are divided equally into training (for creating models) and testing (for evaluating model quality) data sets. Models are composed of a set of conditional rules developed through an iterative process of rule selection, evaluation, testing, and incorporation or rejection. First, a method is chosen from a set of possibilities (e.g. logistic regression, bioclimatic rules, etc), and applied to the training data set. Then, a rule is developed

by a number of means (mimicking DNA evolution: point mutations, deletions, crossing over, etc.) to maximize predictive accuracy. Rule accuracy is evaluated via the testing data, as a significance parameter based on the percentage of points correctly predicted as present or absent by the rule. The change in predictive accuracy from one iteration to the next is used to evaluate whether a particular rule should be incorporated into the final rule-set. The algorithm runs either 1000 iterations or until addition of new rules has no effect on predictive accuracy. The final rule-set (the ecological niche model) is then projected onto a digital map of native or potentially invaded areas to identify a potential geographic distribution. Although these environmental variables cannot represent all possible ecological-niche dimensions, they likely represent (or are correlated with) many influential ones in delineating the species' potential distribution.

Spatial predictions of presence and absence can hold two types of error: omission (areas of known presence predicted absent) and commission (areas of known absence predicted present) (Fielding and Bell 1997). Because GARP does not produce unique solutions, we followed recently published best practices approaches to identifying an optimal subset of resulting replicate models (Anderson *et al.* 2003). For each analysis, we developed 100 replicate models; of these models, we retained the 20 with lowest omission error. Finally, from these 20, we retained the 10 with moderate commission error (i.e., we discarded the 10 models with area predicted present showing greatest deviations from the overall median area predicted present across all models). This 'best subset' of models was summed to produce final predictions of potential distributions.

To validate our model predictions, we evaluated their ability to predict independent sets of test points compared with that

expected under random models. Because test results depend critically on how occurrence points are divided into training and testing data sets (Fielding and Bell 1997), we used a 2×2 checkerboard approach (splitting available points into quadrants above and below median latitude and median longitude) that presents a maximum challenge to the model—prediction into broad areas from which no occurrence information was available (Peterson and Shaw 2003). Ecological niche models based on localities in two of the quadrants ('on-diagonal') were used to predict the distribution of the occurrences in the other two quadrants ('off-diagonal'), and vice versa. Models were validated via chi-square tests that incorporate dimensions of correct prediction of both presences (based on independent test data) and absences (based on expected frequencies) (Peterson and Shaw 2003). Random expectations were calculated as the product of the proportional area (within 500 km of known occurrences) predicted present and the number of test presence points. Observed frequencies of correct and incorrect predictions of presence were then compared with expectations using a χ^2 test (1 df).

RESULTS

The native-range predictions based on the two independent spatial subsets of the available occurrence data were closely similar to one another (Fig. 2), with the exception that the model based on on-diagonal quadrants was somewhat more extensive in the north and the south. Both predicted areas in the 'other' quadrants (from which occurrence data were withheld from the modeling exercise) that coincided well with the test points in those areas (both $\chi^2 > 23.90$, both $P < 10^{-10114}$). Although the two reciprocal predictions are not identical, their substantial significance nonetheless indicates clear predictive ability of our models for distributional phenomena related to this species.

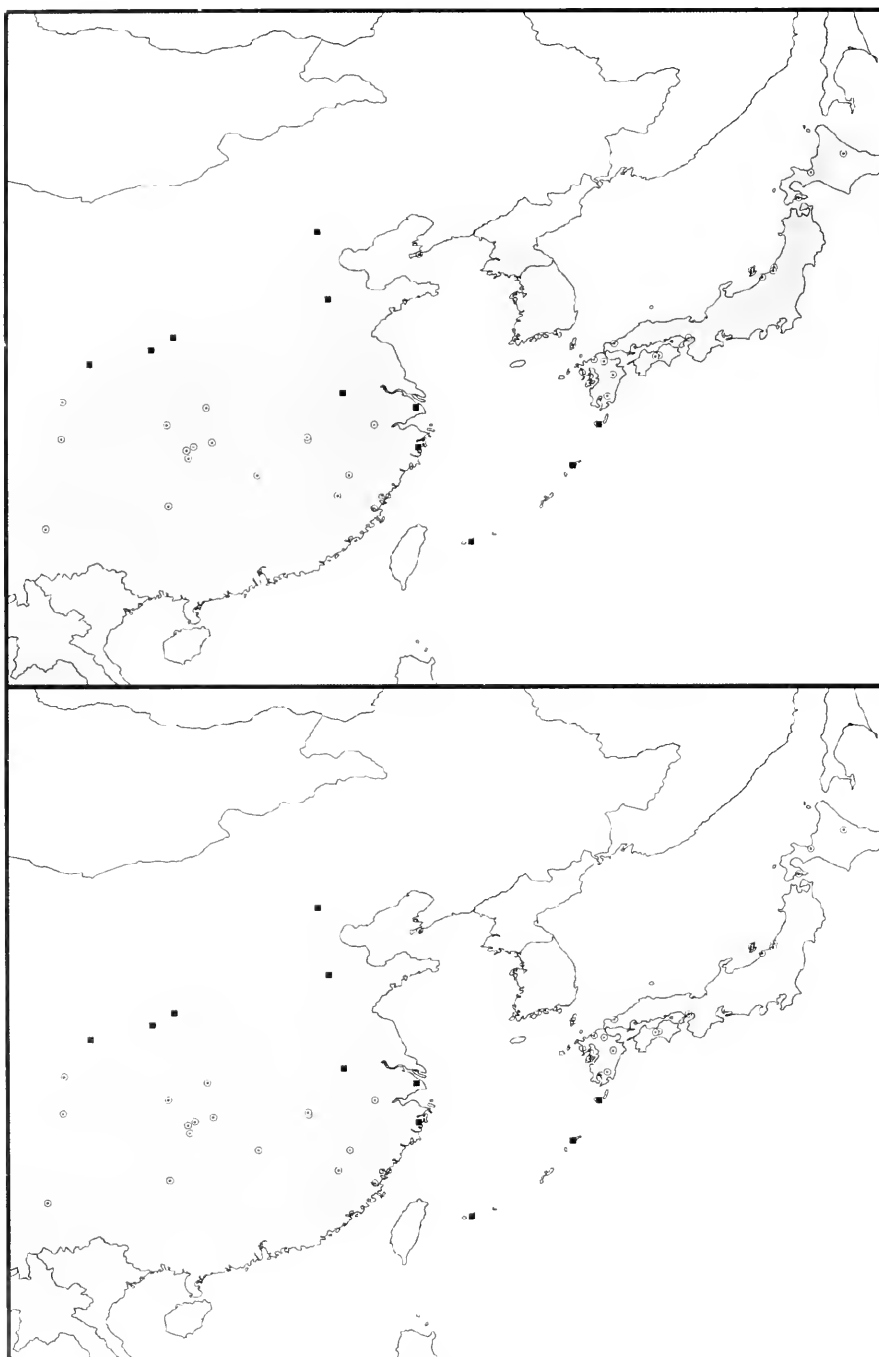


Fig. 2. Predictions of native geographic distribution of *Megachile sculpturalis* Smith, based on two distinct subsets (here depicted as squares versus circles) of the available data-on-diagonal quadrants predict off-diagonal quadrants (top), and vice versa (bottom).

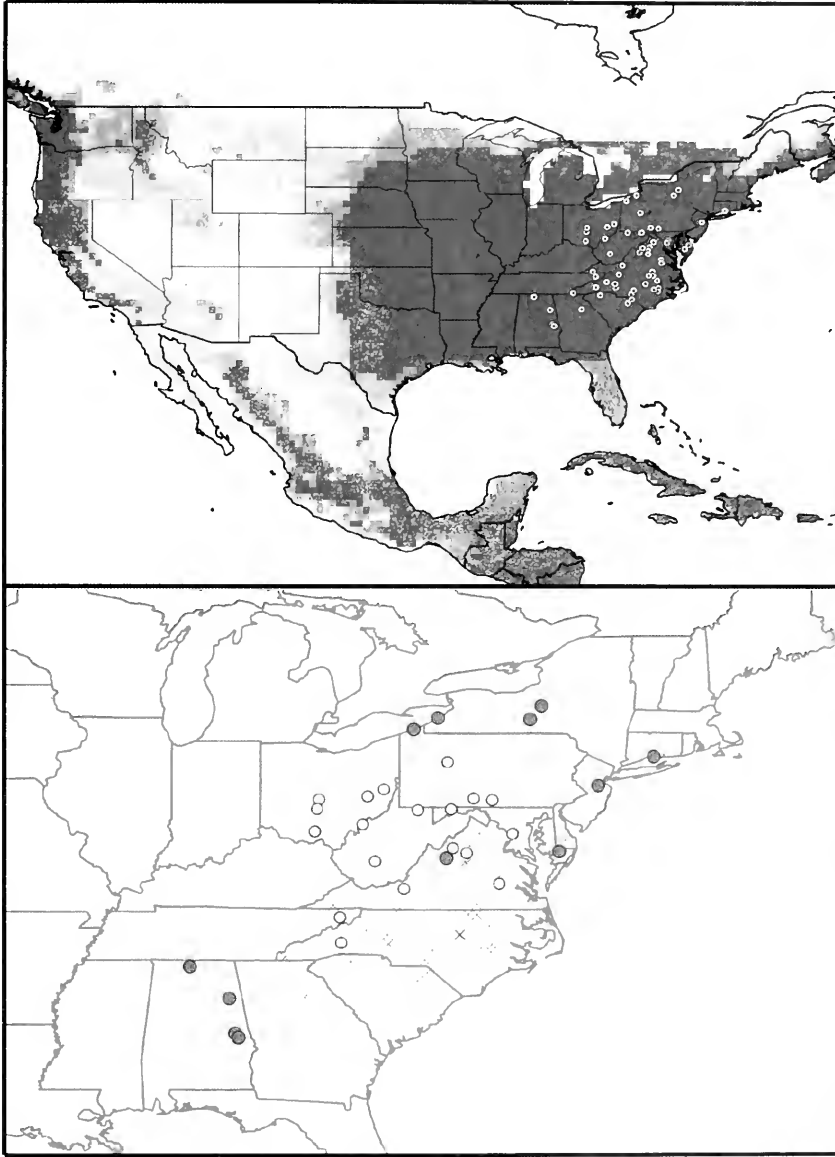


Fig. 3. Projection of native-distribution ecological niche model for *Megachile sculpturalis* Smith to the United States, identifying areas putatively suitable for the species (top); observed pattern of advance (year of first detection) of invading populations (bottom): X's = 1994–1997, light gray circles = 1998–1999, and dark gray circles = 2000–2001.

Thus, we combined all native-range occurrences to build a single model for projection to North America.

Projecting our native-range ecological niche model to North America, broad areas were identified as suitable for this species to maintain populations (Fig. 3).

These areas included the entire eastern half of the continent, west as far as the Great Plains. The models also identified disjunct areas of potential distribution along the Pacific Coast; in western, central, and southern Mexico; and in the West Indies. As such, the potential distribution

of *M. sculpturalis* in North America appears to be quite extensive.

DISCUSSION

The potential invaded distribution in North America predicted by our ecological niche model for *M. sculpturalis* considerably exceeds the earlier prediction of Batta (1998). Both predictions agree that the species will come to occupy the humid eastern United States; our model, however, also shows a broader potential to the west and north of the area outlined by Batta (1998). In other words, instead of extending only west to eastern Texas, the species will likely reach northwestern Texas and western Kansas. Similarly, instead of ending in southern New England, the species will likely reach north to Nova Scotia, Canada (Fig. 3).

Projection of our model onto all of North America identified additional potential areas of invaded distribution for the bee *outside* the present eastern range discussed above. These areas are along the Pacific Coast of the United States, portions of Idaho, and parts of Mexico and the West Indies (Fig. 3). These predictions are—it should be remembered—of *potential* distributions only; as such, the species would likely establish populations only if presented with dispersal opportunities that would place them in or close to those areas. Given the potential ecological suitability identified and high import traffic from Asia along the western seaboard there would, however, appear to be a high probability of an independent North American introduction of this species into northern California, and eastern Oregon and Washington. The West Indies also seems to be a credible region into which *M. sculpturalis* might invade. A related species, *M. (Callomegachile) rufipennis* (Fabricius) from Africa, is already adventive in the West Indies (e.g., Mitchell 1980, Genaro 1997), reinforcing the notion that, if introduced, *M. sculpturalis* could easily

become established and widespread on these islands.

The growing number of collection records of the bee in North America so far confirms the predictions presented here. Indeed, plotting known North American occurrences by year (Fig. 3) shows the broadening spatial pattern of occurrence of the species through time. Continued surveying of this species over time will provide much more concrete tests of our predictions, particularly in states such as Kentucky, Illinois, Indiana, Missouri, and Mississippi as well as more western localities in Tennessee. Such surveys will be important for documenting the spread of *M. sculpturalis*. Surveying for *M. sculpturalis* is not difficult, given its impressive size; even indirect records can be accumulated via the marks it leaves on flowers while foraging (Mangum and Sumner 2003). Possible impacts of *M. sculpturalis* on native *Megachile* species, other native bees, or as a pollinator, are entirely unknown. Although it has been seen using abandoned nests of native carpenter bees (Mangum and Sumner 2003), its foraging activities have so far been recorded principally on exotic plants. For the moment there is little reason to *a priori* suspect any barriers to the bee's continued westward invasion of the North American continent.

ACKNOWLEDGMENTS

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***Pseudoscolia*: A Spheciform Wasp with a Pointed Glossa (Hymenoptera: Crabronidae)**

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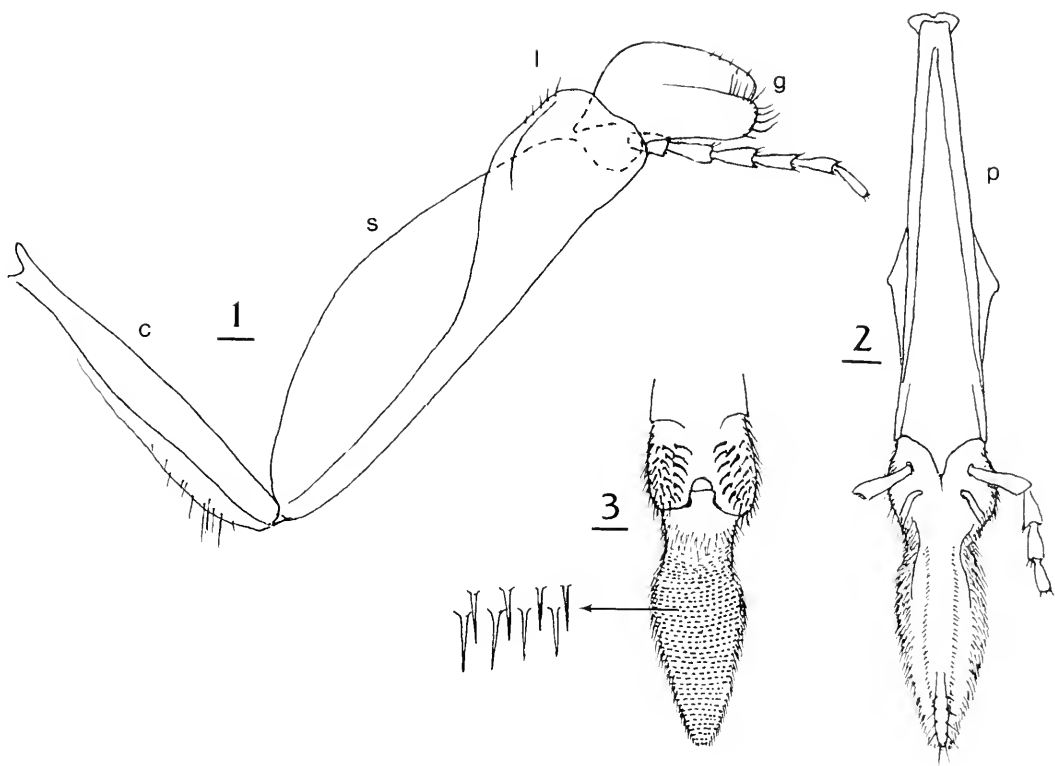
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Abstract.—The philanthine genus *Pseudoscolia* Radoszkowski differs from other apoid wasps in having a narrow, pointed glossa similar in details to that of many short-tongued bees. Its other characters, however, even those of other mouthparts, resemble those of other philanthine wasps. Therefore the glossal shape of *Pseudoscolia* is presumably not homologous to that of bees, but was independently derived from the truncate or bilobed wasp glossal shape. Such a shape in colletid bees is not homologous to that of wasps, but is believed to be based on a different part of the glossa. The pointed glossa of *Pseudoscolia* suggests that it is reasonable to speculate that the ancestral bee had a pointed glossa.

On reading a paper by Prentice and Pulawski (2004), I was surprised to learn that there exists a genus (*Pseudoscolia* Radoszkowski) of philanthine wasps with a pointed glossa, a fact curiously ignored in major works on the group (Bohart and Menke 1976; Alexander 1992). Although named in 1876 and with 35 currently recognized species (W. Pulawski, pers. comm.), *Pseudoscolia* was first recognized as having a pointed glossa by Prentice (1998) in an as yet unpublished resource. Other spheciform wasps (i.e., wasps in the superfamily Apoidea, or apoid wasps) have the broad truncate or bilobed glossal shape characteristic of most Hymenoptera. The existence of a spheciform wasp with a pointed glossa is of interest to students of bee evolution because there are two views about the glossal morphology of the ancestral bee, i.e., the protobee from which modern bees evolved. One view is that it had a truncate or bilobed glossa like that of spheciform wasps (other than *Pseudoscolia*), and as do all females and nearly all males of the modern bee family Colletidae. The spheciform wasps are the paraphyletic group from within which the

bees arose (for more information see below). The truncate or bilobed glossa is the principal character indicating that the Colletidae, having retained as a plesiomorphy the broad glossa from wasp ancestors, is the basal branch of the bee phylogeny, the sister group to all other bees. The alternative view is that the ancestral bee had a pointed glossa and that the truncate or bilobed glossa of Colletidae is a derived feature used by females for painting the cell lining onto the walls of the brood cells (something wasps do not do). Such a broad glossa is similar in shape to that of the wasps, but under this scenario would be interpreted as a synapomorphy rather than a plesiomorphy of the Colletidae.

Although not obvious in all colletids, it appears that the preapical fringe of the colletid glossa is at the apex of the annulate or anterior surface of the glossa and that the more distal, commonly bilobed part of the glossa and the glossal brush are derived from the disannulate posterior surface (terminology of Michener and Brooks 1984). In apoid wasps, however, the annulate anterior surface extends to the distal margin; there is no preapical



Figs 1–3. 1. Inner view of maxilla of *Pseudoscolia dewitzii*. The galea, which is actually turned obliquely, is turned to same plane as the stipes for illustration. c, cardo; s, stipes; l, lacinia?; g, galea. 2. Posterior view of labium. The mentum is directed away from the observer from the base of the prementum. p, prementum. 3. Anterior view of glossa and paraglossal area. Only the conspicuous bases of the annular hairs are shown; the transparent and almost invisible annular hairs are enlarged at the left.

fringe and no glossal brush, although apical setae may resemble a sparse brush. Thus it appears on anatomical grounds that the broad, usually bilobed apex of the glossa is different in derivation in wasps and in colletid bees. Unfortunately there are colletids in which the anatomical evidence is not very clear (see Michener 1992), so the above interpretation, while probable, is not unassailable.

Recent works have provided a basis for understanding the phylogeny of major lineages of aculeate Hymenoptera. The superfamily Apoidea (apoid or spheciform wasps and the bees) is monophyletic, as shown by Melo (1999) and Brothers (1975). The Apoidea is divisible into the following families: Heterogynaidae, Ampulicidae,

Sphecidae s. str., Crabronidae, Colletidae, Stenotritidae, *Andrenidae, *Halictidae, *Melittidae, *Megachilidae, and *Apidae (Michener 2000a: 60). The first two are groups with plesiomorphic characters such that they are basal branches of cladograms for apoid families. The Sphecidae s. str. forms the next branch, the sister group to the remaining families, Crabronidae + the bees. [Lomholdt (1982), who recognized the relationships among the bees and the paraphyletic group called spheciform wasps, used the name Larriidae for the group now called Crabronidae.] Finally the Crabronidae is the sister group to the bees. Some authors such as Lomholdt (1982), Gauld and Bolton (1988), and Melo (1999) prefer to unite bees under

the family name *Apidae s. lato*. Synapomorphies for the bees as a whole, separating them from the Crabronidae, are listed by authors such as Melo (1999), Roig-Alsina and Michener (1993), Alexander and Michener (1995), and Michener (2000a, b). As to apomorphies of Crabronidae, the most striking is the bifid salivary opening of the larva, differing from that of bee larvae as well as other Hymenoptera.

Of the families of the superfamily Apoidea listed above, those marked by asterisks have pointed glossae, certainly a derived feature relative to the broad glossa of other Hymenoptera. As indicated above, recent authors (Radchenko and Pesenko 1994, 1996; Michener 2000a, b) doubt the view that the shape of the broad colletid glossa is homologous to the similar shape of the glossa of wasps. This doubt was first developed because three genera of obvious colletid bees have pointed glossae in males, suggesting that the broad glossa of Colletidae arose first in females in connection with application of the cellophane-like brood cell linings characteristic of nests of Colletidae. Perkins (1912) and McGinley (1980) were the first to suggest that the pointed glossa of a few male colletids might be ancestral for bees, hence the appellation "Perkins-McGinley Hypothesis."

MATERIALS AND METHODS

A male and a female of *Pseudoscolia dewitzi* (Kohl) from Egypt, determined by W. J. Pulawski, were used. The mouthparts and terminalia were dissected out, treated mildly with KOH solution at room temperature, washed in water, and studied in glycerin, using magnifications up to 200×. For comparison, specimens of *Cerceris compacta* Cresson, *Philanthus bicinctus* Mickel and *P. gibbosus* (Fabricius) were similarly treated.

The proboscis is regarded as projecting downward from the head. Thus the anterior surface of the glossa is the surface that would be dorsal if the proboscis were con-

sidered to project forward, and the posterior surface would be called ventral in that case.

The terminology used for glossal structures is that of Michener and Brooks (1984). I use the word 'seta' for a hair-like projection arising from a socket-like base, and the word 'hair' for such a projection not arising from a socket, its base spreading onto the cuticular surface.

GENUS *PSEUDOSCOLIA*

This genus of philanthine wasps is found from the Canary Islands and North Africa east through the Middle East and Central Asia to eastern Siberia, and south to Kenya (Prentice and Pulawski 2004). It is a basal member of the *Cerceris* clade, the tribe Cercerini, according to Alexander (1992). Except for the glossa, its characters are those of related Crabronidae and not those of bees. Thus the setae are simple, the hind basitarsus is slender, the seventh metasomal tergum of the female is continuous dorsally (not divided into lateral hemitergites as in bees), the posterior strigil of the hind leg is present (although weakly developed), the seventh and eighth metasomal sterna of the male are not modified as in bees, bristles are numerous on the outer surfaces of the middle and hind tibiae, and the pretarsal claws are simple (not cleft as in many bees). Wasp systematists tend to give little attention to the labiomaxillary complex which in dead specimens is often retracted and hard to study. However, it is reasonable to believe that all species of the genus have an acute glossa; Prentice and Pulawski (2004) mention the acute glossa as a generic character. W. J. Pulawski kindly checked all 23 species of *Pseudoscolia* in the collection of the California Academy of Sciences; in two species the glossa was hidden but in 21 the glossa was pointed (pers. comm.).

In *Pseudoscolia dewitzi* the maxilla (Fig. 1) is much like that of related wasps. The galea is short, not elongate in company

with the glossa, as is common in bees. The galeal comb is reduced to a few bristles; probably homologous to the better developed comb of *Philanthus*, *Cerceris* and most Crabronidae, but not homologous to the more basal galeal comb of many short-tongued bees. It is possible that the small size of *P. dewitzii* is associated with the reduction of some structures (such as galeal comb and paraglossa) relative to those of *Philanthus* and *Cerceris*.

Because of the short galeae, the glossa protrudes by itself (Figs. 1, 2). One wonders how it functions; in short-tongued bees with a pointed glossa the galeae generally form a partial sheath around the glossa, movements of which apparently draw up the nectar (Harder 1983). The labium, including the glossa, are shown in Figure 2; the mentum is directed at right angles away from the observer at the base of the prementum and is therefore scarcely shown. [Galeae are also elongate in the Sphecidae s. str. such as *Ammophila* which have a long but bifid glossa (Ulrich 1924).]

The distal parts of the paraglossae are greatly reduced compared to *Philanthus* and *Cerceris* but their basal parts are broad and armed with coarse, blunt, curved, spine-like setae (Fig. 3) on the anterior surfaces.

The glossa is remarkably similar to that of short-tongued non-colletid bees (i.e. families Andrenidae, Halictidae, Melittidae). The anterior surface of the glossa is transversely annulate (Fig. 3), the annuli evident because of the transverse rows of bases of the annular hairs. The annular hairs are simple, tapering to sharp points. Laterally the annuli extend around the sides of the glossa and end in abundant marginal hairs, much as in Fig. 5 of Michener and Brooks (1984).

The disannular surface of the glossa is a delicate membrane that occupies much of the posterior surface (Fig. 2). It lacks annuli and annular hairs (except perhaps laterally where it is difficult to judge whether annuli extend onto the posterior surface

among dense marginal hairs). Mesal to the marginal hairs the posterior surface the glossa is hairless except for two rows of seriate hairs (Fig. 2) which are short, simple and divergent, being directed distolaterally. The seriate hairs mark the seriate lines of Michener and Brooks (1984).

An elongate, weakly sclerotized body, probably to be called a flabellum, lies on the apex of the posterior surface of the glossa; it bears pairs of setae laterally (Fig. 2). A remarkably similar flabellum is found in *Ctenoplectra* (Fig. 57, Michener and Brooks 1984) but in that melittid bee it extends distally beyond the apex of the rest of the glossa, as does a typical flabellum. The distinctive sensilla of the basiglossal sclerite of bees are not evident in *Pseudoscolia*. In contrast to many colletid bees (Michener 1992), there are no obvious sexual differences in the glossa of *Pseudoscolia*.

DISCUSSION

The elongate, pointed glossa of *Pseudoscolia* is presumably an apomorphy of the genus and its shape is almost certainly not homologous to the shape of the pointed glossa in the bee families Melittidae, Andrenidae, Halictidae, the long-tongued bees, and also in a few male Colletidae. Its importance for understanding bee phylogeny is that it demonstrates that it is not outlandish to believe that the protobee (a close relative of, perhaps sister to, the Crabronidae) had a pointed glossa. Such a glossa is not in the ground plan of the Crabronidae, but since it evolved within that family (producing *Pseudoscolia*), there might have been the potential for the evolution of a very similar complex structure in the sister group, ancestors of modern bees. The pointed glossa could then have been retained in most bees but was replaced by an independently evolved broad, truncate or bilobed glossa in female Colletidae and in males also except for three genera of Hylaeinae.

It is probable that the Hylaeinae is not

a basal subfamily of Colletidae (Alexander and Michener 1995) although its lack of a scopa and transfer of pollen in the crop have sometimes been interpreted as ancestral. If the Perkins–McGinley hypothesis is supported, one must assume that the broad colletid glossa arose as a female character in ancestral Colletidae and that it was transferred at various times to nearly all male colletids, for which it has no known special function. In other words, loss of the pointed glossa in males occurred more than once in colletid evolution, since maintenance of separate glossal structures for the two sexes was not advantageous.

It has to be admitted that the independent origin of a pointed glossa in *Pseudoscolia* could be interpreted to mean that the pointed glossae of males of three hyaline colletid genera could also have arisen independently from the similar pointed glossae of most families of bees. There is no reason to believe, however, that a pointed glossa would be advantageous for male colletids; it seems more like a relic than a novelty.

In contrast to the wasps, whose broad glossa is annulate to the apex on the anterior surface and bears some long apical setae, that of colletids seems to end with extension of the posterior disannulate surface and the glossal brush. The detail of structure in which the pointed glossa of *Pseudoscolia* resembles that of the bee families Andrenidae, Halictidae and Melittidae is remarkable. It is not surprising that when the broad glossa was narrowed for whatever reason, whether for most bees or for *Pseudoscolia*, the ends of the annuli curved onto the sides and the setae scattered across the apex of the broad glossa were concentrated on the midapical flabellum. But how does it happen that the seriate lines and hairs, with no obvious homologues in the broad glossa of other Crabronidae, are as distinct in *Pseudoscolia* as in short-tongued bees?

It would be interesting to observe the

functioning of the glossa of *Pseudoscolia*, for example to see if these wasps obtain nectar from different flowers or in different ways than do other Crabronidae of similar size.

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A New Species of *Geodiscelis* (Hymenoptera: Colletidae: Xeromelissinae) from the Atacama Desert of Chile

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Abstract.—*Geodiscelis longiceps* Packer, new species, is described from northern Chile. Morphologically, it is somewhat intermediate between *Chilimelissa* and *Geodiscelis*, but is clearly more closely related to the latter as indicated by numerous synapomorphies such as the broad basal bands of appressed tomentum, long and thin hind tibial spurs, well developed mesotarsal setae in the female, large and well sclerotised proctiger, angulate mesal margin and elongate inner membranous process to the gonocoxites and absence of a ventroapical process to the gonobase. It differs from the type species of the genus in the enormously elongate head and mouthparts but otherwise normal glossa. Based upon character states shared by the new species and the type species of the genus, a revised diagnosis for *Geodiscelis* is provided. Some comments on the adaptive significance of extremely elongate heads in the Xeromelissinae are made.

The purpose of this paper is to bring attention to an unusual new species of xeromelissine, *Geodiscelis longiceps* Packer, recently collected in Tarapaca Province in the Atacama desert of Chile. It exhibits some characters intermediate between those of the type species of the genus, *Geodiscelis megacephala* Michener and Rozen, and species of the related genus *Chilimelissa* and also a remarkable convergence in head shape to *C. rozeni* Toro and Moldenke. Nonetheless, it is clearly more closely related to *G. megacephala* than to any species of *Chilimelissa* and its array of morphological characteristics permits a more detailed definition of the genus *Geodiscelis*.

In the descriptions, diagnostic characteristics of the new species among all Xeromelissinae are italicized. Except for body length, wing length, head width and length measurements, relative sizes of various structures are given in graticule units solely to indicate relative dimensions rather than the absolute size of particular features. Relative puncture density is given in terms of the ratio of interspaces (i) to puncture diameters (d) and the following standard abbreviations are used: F, T, S

for flagellomeres, and metasomal terga and sterna respectively, IOD for interocellar distance, OOD for ocellocular distance, UOD and LOD for upper and lower ocular distances respectively.

The photographs used in figure 1 were taken with a Nikon coolpix 990 digital camera and amalgamated into one figure using Adobe Photoshop 6.0. The SEM photograph for figure 2 was taken using a Hitachi S520 scanning electron microscope at 20KV.

Geodiscelis longiceps Packer,
new species
Figs 1–6

Diagnosis.—The new species is readily separated from all other species of Xeromelissinae through the combination of pale bands on the metasoma, malar space enormous (longer than compound eye), and maxillary palps of normal form without differentiation of the segments into enlarged basal and reduced apical ones (Fig. 1). Among the Xeromelissinae only some species of *Chilicola* subgenus *Pseudiscelis* have the combination of considerably enlarged malar space and unmodified max-

illary palps (albeit with seven, rather than six, segments) but these lack pale markings on the metasoma. Similarly, males of *Xenochilicola diminuta* Toro and Moldenke are the only previously known xeromelissines with yellow markings on the metasoma and unmodified palps, but their malar space is comparatively short: one quarter as long as the compound eye. *Chilimelissa rozeni* Toro and Moldenke shares the yellow markings and very elongate malar space but it has extreme modifications of the maxillary palps (Fig. 1). The new species shares with *G. megacephala* the presence of long hairs on the middle tarsus (although these are even more strongly developed, into a distinct rake, in the new species, Fig. 2), very long hind tibial spurs, the basal bands of apressed, scale-like pubescence on the metasomal terga (Fig. 1) and details of the male genitalia (Figs 3–5). It differs in certain key characteristics from the type and only other species of *Geodiscelis* in lacking elongate apical lobes to the glossa, in the absence of clavate hairs on the female foretarsus, in having toothed claws in both sexes and in having a narrow stigma. The enormous malar space in the new species makes it possible to tell the two congeneric species apart at a glance.

Description.—*Male*. Body length 4.3mm, wing length 2.3mm, head width 1mm.

Colouration: Black (metasoma dark brown) with following parts yellow: labrum; mandible; malar space; apical mark on clypeus; scape, anterior surface of pedicel and flagellum; mark on tegula; entire foreleg except for brown on base of coxa, dorsal marks on trochanter and femur and ventral mark on tibia; entire midleg except for dark brown coxa and dorsal surface of trochanter and basal half of femur (narrowly yellow ventrally) and ventral mark on tibia; ventral surfaces of hind coxa and trochanter, apical one third of femur, tibia except for posterior brown mark and hind basitarsus; apical bands and ventrally reflexed portions of all metasomal terga; all

metasomal sterna except for brown S1 and basal brown triangle on S2.

Pubescence: White, thickened, almost scale-like, dense on lower paraocular area, margins of scutum, dorsolateral portion of propodeum and basal bands to T1–T4 (covering basal two-thirds of T1); apex of each of mesotarsomeres 1–4 with one extremely long seta, that on basitarsus longer than basitarsus (18:15), that of second mesotarsal segment as long as basitarsus.

Surface Sculpture: Integument somewhat shiny despite dense, though shallow, microsculpture; punctation shallow and sparse on clypeus and supraclypeal area, apparently absent on frons, vertex and paraocular area; very shallow, effaced, largely transverse but more dense (i~d) on scutum, difficult to discern on mesoscutellum and sides of thorax; dorsal surface of propodeum weakly rugulose basally, wrinkled apically.

Structure: HEAD: Considerably longer than mesosoma (61:46) and *more than twice as long as broad* (61:28); mouthparts very long and narrow, galeal blade twice as long as greatest breadth, prementum 15 times longer than greatest breadth; maxillary palps 6-segmented, all segments similar in structure, second segment the shortest, sixth segment the longest, total length less than $\frac{1}{2}$ as long as prementum; labial palps 4-segmented; labrum broader than long (17:11), apex rounded; mandible without preapical tooth; malar space enormous, longer than greatest dimension of compound eye (48:36), malar line absent; clypeus three times longer than greatest breadth which is just basal to epistomal lobes; supraclypeal area three times longer than wide; lower ocular tangent passing through basal one-fifth of supraclypeal area; compound eye broad, length to breadth 35:25, ventral margin flat and interrupting profile of gena in lateral view; upper ocular tangent passing below median ocellus; ocelloccipital distance greater than diameter of lateral ocellus (7:5); OOD:IOD 11:15; gena $\frac{2}{3}$ as long as greatest

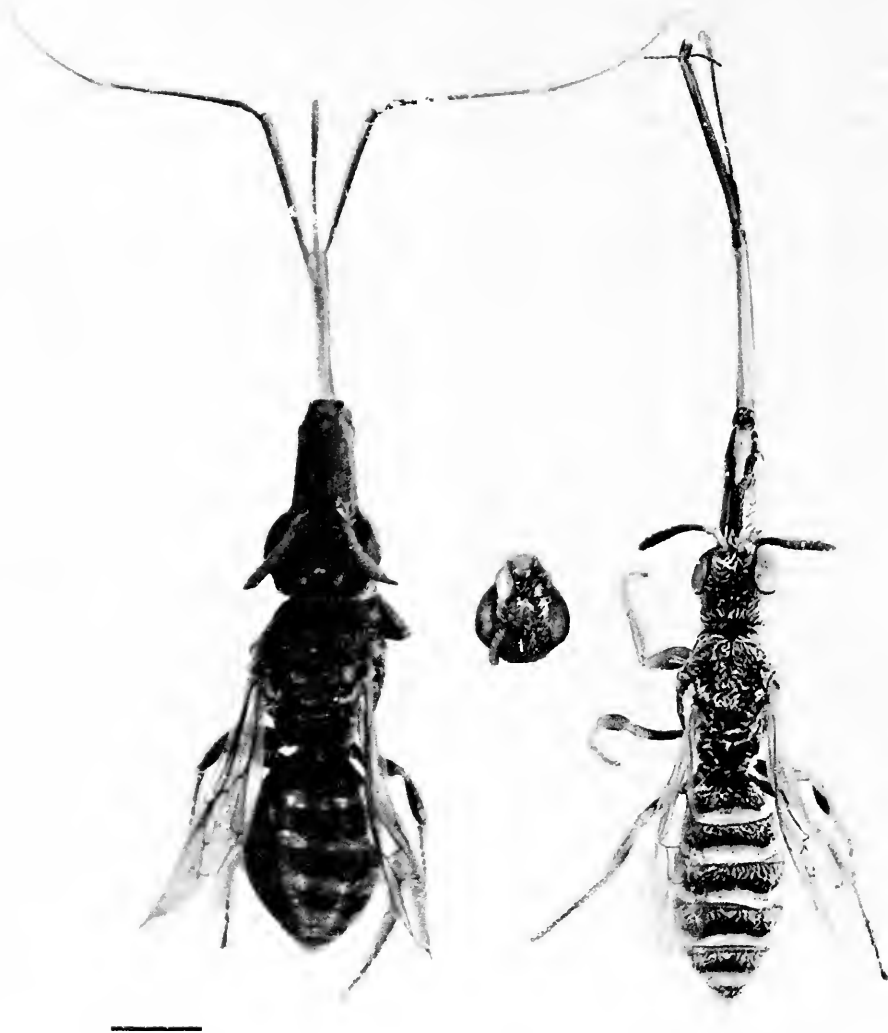


Fig. 1. Habitus photographs of *Geodiscelis longiceps*, right, and *Chulimelissa rozeni*, left, to show similarity in head shape and dissimilarity in mouthparts. Whereas the cardines and stipites of both species are elongate, the maxillary palps (artificially oriented laterad in both preparations) are enormous only in the latter species, the basal two segments being short, segments 3 and 4 being enormous, and the apical two segments again being short. Note that the maxillary palps of *C. rozeni*, when in use, extend considerably beyond the apex of the glossa whereas in *G. longiceps* the glossa attains the apex of the mouthparts. The head of *G. megacephala* is shown between the other two bees for comparison. Note that the pale metasomal bands of *C. rozeni* were artificially darkened in this specimen due to storage in buffered formalin. Scale line = 1mm.

width of compound eye; vertex in dorsal view slightly constricted behind compound eye; scape short, length to breadth 15:6; pedicel as broad as long, not narrowed towards base; F1 subtriangular,

strongly narrowed towards base, remaining flagellomeres somewhat longer than broad, cylindrical.

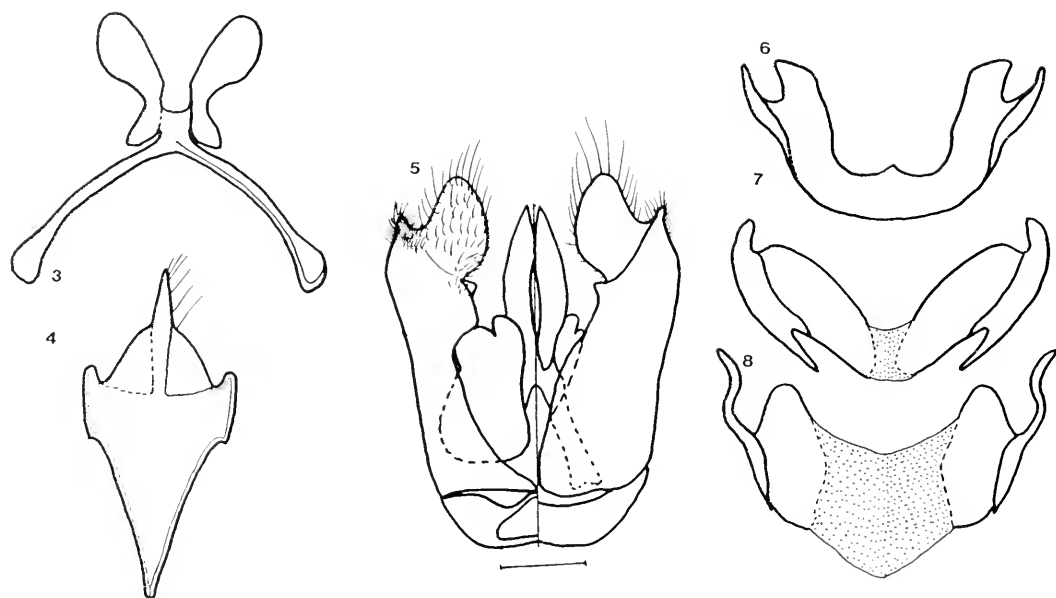
MESOSOMA: Elongate, distance from posterior margin of pronotal lobe to inser-



Fig. 2. Mesotarsal rake of female *G. longiceps*, SEM. Scale line = 0.1mm.

tion of metasoma greater than greatest depth of mesothorax (52:42); dorsal surface of propodeum depressed at base, concave in profile with slight swellings posterolaterally, longer than both metanotum and mesoscutellum (ratio of mesoscutellum:metanotum:dorsal surface of propodeum 11:7:13); legs unmodified other than for long setae on mesotarsus and hind tib-

ial spurs very long and fine, longer spur more than two-thirds as long as basitarsus (23:36); stigma with margins basal to vein R diverging, portion in marginal cell slightly concave; first recurrent vein meeting first submarginal cross-vein, second recurrent vein on second submarginal cell. METASOMA: Flattened, broadest at T3, pygidial plate absent; terminalia as in Figs



Figs 3–8. 3, *G. longiceps*, male, S7; 4, *G. longiceps*, male, S8; 5, *G. longiceps*, male, genital capsule; 6, *G. longiceps*, male, proctiger; 7, *G. megacephala*, male, proctiger; 8, *Chilimelissa australis*, male, proctiger. Ventral views on left, dorsal views on right. Scale line = 0.1mm.

3–6; proctiger very large and well sclerotised appearing almost like a normal tergum; S7 with somewhat elongate but comparatively well sclerotised apical lobes, basal lobes considerably reduced, almost absent; S8 elongate and narrow, apex narrowly rounded; gonobase lacking apicoventral projection; gonocoxites with strong apico-medial angle, gonostylus narrow, subapical median lobe large, surpassing posterior extremity of gonostylus.

Female: As in male except for usual secondary sexual characteristics and as follows: larger, body length 4.8mm, wing length 2.8mm, head width 1.1mm.

Colouration: With yellow mark on pronotal lobe, forefemur with larger dark mark.

Pubescence: More extensive on scutum and sides of mesothorax; basal hair bands of metasomal terga broader and present on T1–T5; foretarsus without clavate hairs; mesotarsus with well developed rake of long setae, considerably longer than basitarsus (up to 28:17, Fig. 2), mesobasitarsus with dense patch of shorter hairs along

anterior margin; weak scopa on hind tibia; scopa of S2 composed of unbranched hairs.

Structure: Mandible with small preapical tooth; pedicel somewhat narrowed basally; F2–F9 shorter than broad; hind tibial spurs two-thirds as long as metabasitarsus; first and second recurrent veins originating on second submarginal cell; propodeum twice as long as metanotum, slightly shorter than mesoscutellum (ratio of lengths of mesoscutellum:metanotum: dorsal surface of propodeum 16:7:14).

Type material.—Holotype male, allotype female, 7 male and 19 female paratypes: CHILE, Region 1, Tarapaca, 29km marker on Hwy 687, 62km ESE of Pozo Almonte, S20°17'425" W069°12'97", 2510m 8–20.iv.2004, L. Packer, pan traps. An additional female, same data, is in glycerin and 8 females same data except 9.iv.2004, collected from flowers, are stored in alcohol. All specimens including the holotype and allotype are housed in the author's collection at York University with the exception of 2 individuals stored in alcohol which

are in the Department of Entomology, Cornell University, Ithaca, New York. One female will be deposited in each of the following institutions: American Museum of Natural History, New York; the Snow Entomological Museum, University of Kansas, Lawrence, Kansas; USDA bee lab, Logan, Utah; Museo Bernardino Rivadavia, Buenos Aires, Argentina; Museo Nacional de Historia Natural, Santiago, Chile; and the Zoological Institute of St. Petersburg, Russia.

Etymology.—The specific epithet refers to the extreme elongation of the head in this species.

DISCUSSION

Based upon phylogenetic analysis of a large data set for all genera, subgenera and species groups of xeromelissine bees (Packer, in preparation), the new species shares numerous synapomorphies with *G. megacephala*, the type, and hitherto only, species of the genus. The following character states thus form a revised diagnosis for the genus *Geodiscelis* and are unique to it among all Xeromelissinae: elongate "rake" of hairs on the mesotarsus; basal bands of appressed scale-like tomentum to metasomal terga; hind tibial spur elongate, two-thirds as long as basitarsus, and fine, barely any more robust than some of the more elongate hairs on the hind tibia; proctiger well sclerotised with the two lateral portions almost (*megacephala*) or completely (*longiceps*) united; no apicoventral projection(s) to the gonobase; an apicomedial angulation on the gonocoxites; and membranous lobe of gonocoxites extending beyond the gonostylus.

These last two characters require comment. In their Fig. 5, Michener and Rozen (1999) show the apicoventral margin of the gonobase to be incomplete in *G. megacephala*, a condition that renders presence of an apicomedial angulation impossible as, when present, it would arise from a medial portion of the ventral surface of the gonobase. However, in the paratype

specimens of this species available to me, the apicoventral margin of the gonobase is complete as is the case in all Xeromelissinae, although in almost all other taxa it is elaborated into a narrow median projection (*Xenochilicola*, *Chilimelissa*, *Xeromelissa*) or it forms a broadly based apically concave lobe (*Chilicola*). The nature of the apical region of the gonocoxites also requires reinterpretation of the observations of Michener and Rozen (1999). These authors noted the double nature of the apical attachments to the gonocoxites, but considered the shorter one to represent an evolutionary novelty and the longer, more mesal one, to represent the gonostylus. This longer structure arises from the apicomedian surface of the gonocoxites rather than at the apex, and thus appears homologous to the smaller lobe found in most *Chilimelissa* species and also in *Xeromelissa wiluattae* Cockerell (see for example the illustration for *Chilimelissa mucar*, Fig. 327 in Toro and Moldenke, 1979). The condition described here for *G. longiceps* is intermediate between that of *Chilimelissa* and *G. megacephala*.

Additional features which serve to support the monophyly of *Geodiscelis* include the form of S7 and the distinct junction between gonocoxite and gonostylus. In *G. megacephala* the lobes of S7 are considerably reduced and entirely fused to the reduced disc. *Geodiscelis longiceps* represents an intermediate condition between *Chilimelissa* and *G. megacephala* in this feature as its lobes are also comparatively well sclerotised and simple, but are somewhat larger and slightly more complex in shape. Similarly, in both species the gonostylus is very well differentiated from the gonocoxites whereas in most Xeromelissinae the junction between these two structures tends to be poorly demarcated.

With *G. longiceps* showing some intermediate characteristics between *G. megacephala* and *Chilimelissa* species, it could be thought that *Geodiscelis* should be subsumed within the latter genus. However,

phylogenetic analyses (Packer in preparation) indicate a sister group relationship between the two genera and the differences between the two do seem substantial, especially in mouthpart characters that are so often of importance in bee systematics.

All individuals of the species were collected in a small area where only two species of flowering plant were found. One is believed to be a member of the genus *Malesherbia* (Malesherbiaceae) the other, upon which most bees seemed interested, is *Tiquilia atacamensis* (Phil.) A. Richardson (Boraginaceae). Interestingly, the type species of *Geodiscelis* forages exclusively on a species of *Heliotropium*, a closely related genus to *Tiquilia*, although the host of *G. megacephala* has smaller flowers than does *T. atacamensis*. The apparent host of *G. longiceps* has bright blue flowers and golden yellow anthers and although superficially it has an apparently open bowl-shaped structure, it has very deep nectaries (Gengler-Nowak, personal communication). Although most specimens were collected in pan traps adjacent to these plants, large numbers were observed on or flying over these two species of flowers, particularly the *Tiquilia*, or resting on sand adjacent to the plants. Search on additional *Tiquilia* patches at distances of 1, 3 and 10km to the East (all at higher altitude) failed to find additional specimens of *G. longiceps*. The patches where *G. longiceps* was found represented the last vestiges of vegetation heading west from the more vegetated mid altitude Altos de Pica to the east and the vegetation-free desert of the eastern slopes of the Pampa del Tamarugal to the west. The locality is on the border between the arid Andean Piedmont and the interior "absolute" desert, an area with very small amounts of summer rain and rarely any winter rain (Caviedes 1973), but one which has experienced several periods of increased inundation since the last ice age (Betancourt et al. 2000).

The mesotarsal rake of females of the new species appears unique among the

bees (they are not as well developed in *G. megacephala*), although similar structures are common among the sand wasps, albeit on the foretarsi (Bohart and Menke 1976). This feature strongly suggests that this species nests in sand, as is also known for the type species of its genus. Other than *G. megacephala*, the Xeromelissinae have been thought to be stem and twig nesting bees (Michener 2000, 2002). However, it has recently been demonstrated that at least one species of *Chilimelissa*, *C. australis* Toro and Moldenke, also nests in the sand (Packer 2004). Several hours of sifting of the loose sand that collects around the bases of the aforementioned plants and dissection of their dried stems failed to locate any brood cells of the new species.

The extreme elongation of the head and mouthparts of the new species are very reminiscent of *C. rozeni*. However, in the latter species the maxillary palps are considerably modified with segments 3 and 4 both being almost as long as the considerably elongated head such that when combined with the cardines and stipites, the mouthparts are longer than the total length of the body (Fig. 1). In *G. longiceps* the cardines and stipites are proportionately even longer than those of *C. rozeni* but the maxillary palps are entirely unmodified, totaling less than $\frac{1}{4}$ the length of either the cardines or stipites and only one half as long as the malar space. One wonders about the adaptive significance of such elongate heads and mouthparts in these bees. *Chilimelissa rozeni* has been found foraging upon the flowers of *Nolana alba* Phil. to the east of Chañaral on either side of the border between Chile's regions II and III (Packer, Zayed and Grixti unpublished observations). This flower has a very long corolla and a very long tongue is required to reach the nectaries (as shown for *Nolanomelissa toroi* Rozen foraging on a related *Nolana* species by Rozen [2003]). It seems likely that the elongate maxillary palpi of *C. rozeni* causes nectar to move up to the glossa, which ends at

the base of the maxillary palpi, through capillary action. The enormous tongues of *C. rozeni* are clearly sometimes a liability in that it often takes the bees several seconds to retract them when disturbed whilst in the flowers and tongue retraction seems to be required before flight occurs (Packer, Zayed and Gixti, unpublished observations). Observations of foraging *G. longiceps* suggest a somewhat different explanation for the unusual head and mouthpart modifications in this species. While foraging for nectar, these bees do not enter the flowers, but instead, sit on the petals with their elongate heads in an approximately horizontal orientation over the open corolla of the flower. The long tongue then protrudes almost perpendicularly, ventral to the insect. It seems that the elongate tongue permits access to the deep nectaries while the insect remains on the top of the flower. This permits visual inspection of the surroundings while feeding, which is not possible when bees have their heads deep within the corollas of deeper flowers. Perhaps avoidance of predators is an adaptive explanation for this unusual combination of behaviour and morphology.

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Cenocoelius huggerti, the First Record of the Subfamily Cenocoeliinae (Hymenoptera: Braconidae) from Africa

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Abstract.—A new species of cenocoeliine braconid, *Cenocoelius huggerti* Pitz and Sharkey sp. n. is described from a single specimen collected in the Gambia, Africa. This represents the first species of Cenocoeliinae described from the Afrotropical region.

The subfamily Cenocoeliinae is relatively small with approximately 65 described species (Achterberg 1997, Braet and Achterberg 2001). The few cenocoeliines with known biologies are koinobiont endoparasitoids of xylophagous Coleoptera larvae, mainly in the Cerambycidae and Curculionidae (Scolytinae) but to a lesser extent in the Buprestidae and other Curculionidae (Saffer 1982, Shaw and Huddleston 1991). Species of cenocoeliines had been recorded from all continents of the world with the exception of Africa (Achterberg 1994) until the discovery of *Cenocoelius huggerti* Pitz and Sharkey sp. n. Although cenocoeliines are now known to be cosmopolitan, they are predominantly found in the neotropics.

Placement of this African species was hindered by the poorly defined genera of Cenocoeliinae. Most species of Cenocoeliinae are placed in the genus *Cenocoelius*. In the most recent revision of the genera, Achterberg (1994) re-instated the genus *Capitonius*; he formally transferred two species to this genus, though he asserted that a majority of New World cenocoeliines belong to *Capitonius* (Achterberg 1997). With no phylogenetic analysis presented, Achterberg (1994) proposed suites of characters to differentiate the genera, but he did not posit autapomorphies for the genera. Without this framework, his

key, diagnoses, and descriptions must be used to understand his generic concepts. Preliminary phylogenetic analyses (Pitz, in prep.) suggest other genera within the subfamily, though morphologically distinct, render *Cenocoelius* and *Capitonius* paraphyletic. We place the African species in *Cenocoelius* based on the lack of characteristics that would place it in *Capitonius* (vertex depressed medially and ratio of veins M+Cu:1-M of hind wing 1.2–2.1) or any of the other small, morphologically distinct genera of Cenocoeliinae.

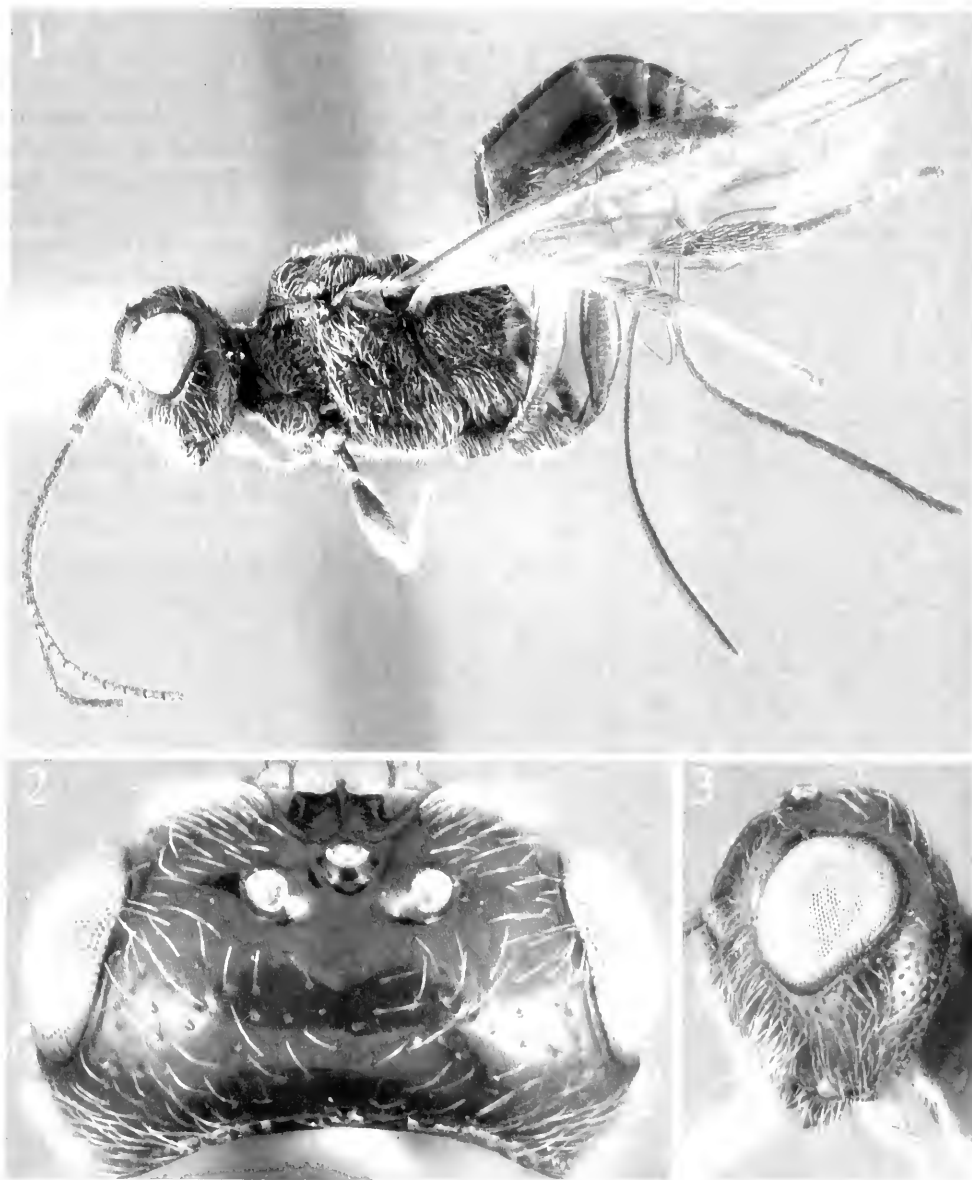
MATERIALS AND METHODS

Generic identification was accomplished using Achterberg's (1994) key to the genera of Cenocoeliinae. The specimen was compared to original descriptions and determined specimens of *Cenocoelius* to establish that it represents a new species.

Morphological terminology used follows that of Sharkey and Wharton (1997). All photographs were taken using a JVC KY-F75 3CCD digital camera attached to a Leica MZ-16 stereoscope and were prepared using an Auto-Montage® imaging system.

Cenocoelius huggerti Pitz and Sharkey
sp. n.

Etymology.—Named after Lars Huggert, the recently deceased Swedish entomolo-



Figs 1–3. *Cenocoelius luggeri* holotype female. 1, lateral habitus. 2, dorsal view of head. 3, lateral view of head.

gist and collector of the only known specimen of this species.

Description.—Holotype Female (Fig. 1). **Length:** 4.9mm. **Color:** body mostly melanic except testaceous as follows: fore tibia, fore tarsus, mid and hind tibiae apically, mid tarsus except basal tarsomere; wings hyaline. **Head** (Figs 2–4): antennae

broken, 15 flagellomeres remaining on left and 11 on right, each flagellomere with two to three rows of longitudinal placodes; median ocellus in antennal scrobe, lower than lateral ocelli; vertex smooth, with moderately dense weak punctures and setae laterally; antennal scrobe deeply impressed, extending to lateral ocelli, ver-

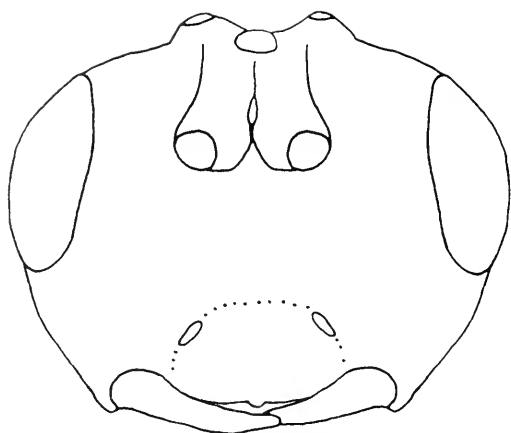
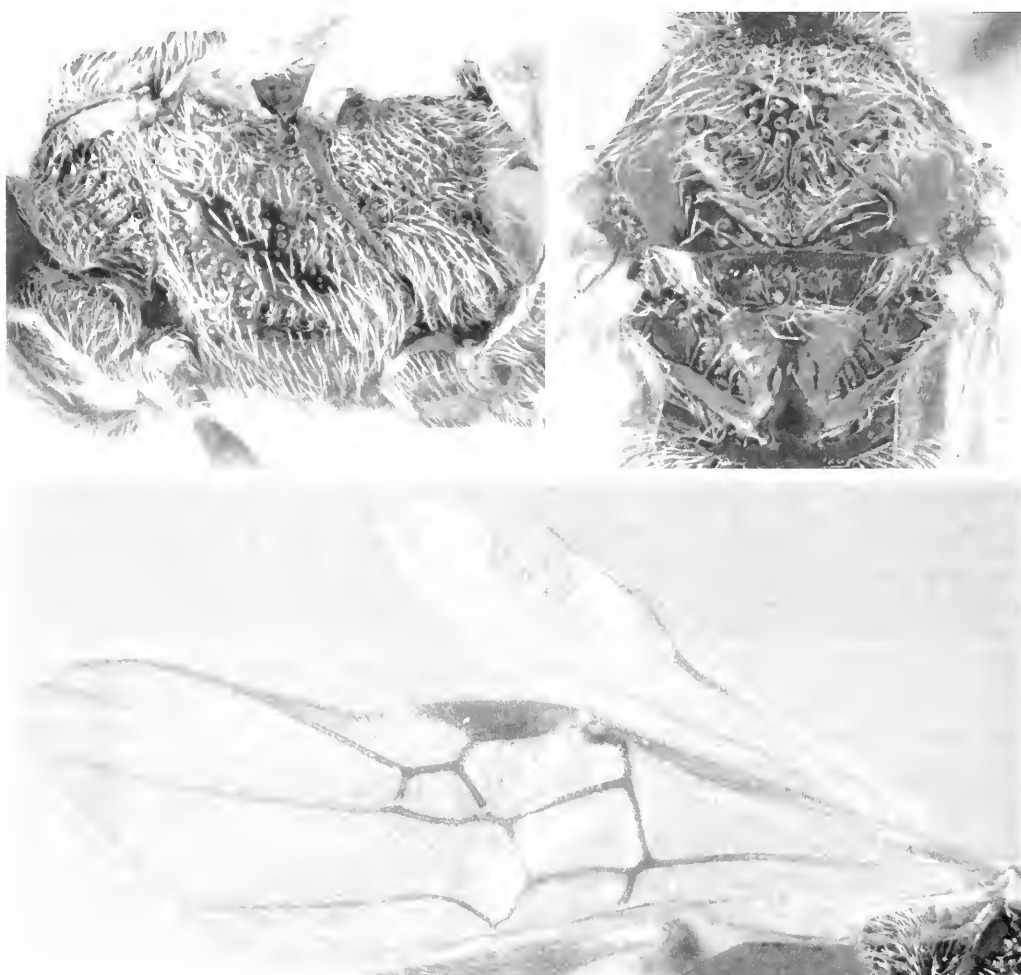


Fig. 4. *Cenocoelius huggerti* holotype female, anterior view of head.

tex flat to convex; lateral carina bordering antennal scrobe reduced, ending immediately anterior to lateral ocellus; median lamella of antennal scrobe sharp anteriorly and posteriorly, flattened over mesal third, protruding slightly above scrobe; face and clypeus smooth with moderately dense punctures and setae; ventral margin of clypeus with one medial tooth. **Mesosoma** (Figs 5–6): pronotum with small oval pronope, subpronope absent, rugosopunctate anteriorly, with rugose transverse depression across entire width with numerous longitudinal carinae, smooth with moderate punctation posteriorly; mesoscutum punctate to foveate on anterior



Figs 5–7. *Cenocoelius huggerti* holotype female. 5, lateral view of mesosoma. 6, dorsal view of mesosoma. 7, wings.

surface, medial lobe with large irregular fovea and moderately dense setae, lateral lobes mostly smooth with sparse setae; notauli meeting slightly anterior to transscutal articulation, with perpendicular carinae that create mostly large oval cells in notauli; scutellar sulcus with four fovea; scutellum smooth with moderately dense setae; propleuron rugosoareolate with moderately dense setae; mesopleuron with fovea on posterior border and dorsomedially, otherwise smooth with moderately dense setae; sternaulus complete, composed of single row of large fovea; metapleuron and propodeum irregularly rugosoareolate, with moderately dense to dense setae; medial face of hind coxa with well defined depression angled anteroventrally, ending ventrally just anterior to middle of coxa, without carina anteriorly; tarsal claws each with quadrate basal lobe. **Wing** (Fig. 7): crossvein r-m of forewing present, second submarginal cell present; ratio of veins M+Cu:1-M of hind wing 3.3. **Metasoma**: first median tergite with two strong carinae basally, otherwise smooth; second and third median tergites smooth; length of first median tergite 1.5 times its apical width; length of ovipositor:length of forewing ratio approximately 0.80–0.90.

Notes.—Right hind wing glued to point
Biology.—Unknown

Male.—Unknown

Material examined.—Holotype female: W[est] Africa: Gambia, Bakau, 19.I.1978, L. Huggert. Deposited in Canadian National Collection.

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A New Host Record for the Afrotropical Parasitic Wasp Genus *Bathyaulax* Szépligeti (Hymenoptera: Braconidae: Braconinae) Confirmed using DNA Sequence Data

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Abstract.—An apparently undescribed species of the braconid wasp genus *Bathyaulax* Szépligeti from Kibale National Park, Uganda, is recorded as a parasitoid of the callichromine cerambycid beetle, *Chromalizus fragrans* (Dalman) subspecies *cranchii* (White), a borer of ‘forest mahogany’ tree, *Trichilia dregeana* Sond. (Meliaceae). The association was confirmed using DNA sequencing of a parasitoid pupa recovered from the pupal chamber of the beetle. A gabuniine cryptine ichneumonid wasp, *Gabunia* aff. *togoensis* Krieger, was also confirmed as a parasitoid of the same beetle. These rearings are discussed in the light of previous host records.

Key words.—Parasitoid, DNA, *Gabunia*, Ichneumonidae, *Chromalizus*, Cerambycidae, *Trichilia*, Meliaceae, mahogany.

Of the approximately 40 genera of Braconinae that are believed to be endemic to the Afrotropical region (Quicke 1987), host records are available for fewer than five, and some of those records that have been published may well be erroneous. Common problems with records of host-parasitoid associations include misidentifications of the parasitoid, or of the host or misidentification of both, or wrong associations, especially when substrate rearings are involved (Noyes 1994; Shaw 1994, 2003; Quicke 2003). Whilst the majority of braconines are parasitoids of concealed hosts, usually larvae of wood-boring beetles for larger species and groups such as stem-borers, leaf-rollers and leaf-miners for smaller ones, the lack of reliable host data for the great majority of species is hampering our understanding of the factors that permit coexistence of so many species of parasitoids with essentially similar life histories.

DNA sequencing provides a powerful tool to confirm host parasitoid associations where cryptic hosts are involved because it enables identification of otherwise, at least currently, unidentifiable host and parasitoid immature stages (Quicke et al. 2003; Laurenne & Quicke 2004). This can be likened to a bar-coding approach (Hebert et al. 2003a,b), and in principle food-webs can be constructed and analysed largely based on taxa whose actual identities are only known approximately—appropriate DNA sequences will usually allow placement to genus or species group. For tropical studies, this actually may not be very different from current morpho-taxonomic studies, as many of the taxa are likely unidentifiable to anything more precise than morpho-species, and even generic placement can sometimes be problematic for many less well-known insect groups.

Here we use DNA sequencing to con-

firm a host-parasitoid relationship for *Bathyaulax* Szépligeti, a poorly known Afrotropical genus of large parasitic braconid wasps, and additionally reveal that a second parasitoid, a member of the cryptine ichneumonid genus *Gabunia* Kriechbaumer, is also involved in the system. The observations also provide a new host tree record for the longhorn beetle involved. Because the tree, 'forest mahogany', is noted for its high quality wood, this may be of some economic significance.

MOLECULAR MATERIALS AND METHODS

We followed the procedures in Laurenne et al. (2000) to obtain 28S D2–D3 rDNA sequence data from the adult *Bathyaulax* and two of the immature parasitoids found in the host's pupation chambers. The sequences for the adult *Bathyaulax* sp. and the presumed conspecific pupa have GenBank/EMBL accessions numbers AY604326 and AY604327 respectively. The sequence of the ichneumonid larva was virtually identical to ones obtained for two Afrotropical *Gabunia* species that will be reported elsewhere as part of a molecular phylogeny of the Cryptinae (GenBank/EMBL accessions numbers AY527195 and AY527196; Laurenne, Broad & Quicke, submitted). Additional braconine 28S rDNA sequences used (EMBL accessions numbers given in parentheses) for comparison are: *Bathyaulax* sp., Kenya (AJ231501), *Bathyaulax cyanogaster* Szépligeti, Nigeria (AY527194), *Monilobracon* sp., Sierra Leone, Lumley (AJ296046), *Iphiaulax* sp., Africa (AJ296052), *Merinotus* sp., Uganda, Kibale (AY296649), *Plaxopsis* sp., Africa (AJ231533), *Latana keijua* Laurenne & Quicke, Uganda, Kibale (AY296638), *Odonotoscopus* sp., Kenya (AJ231503), *Ipobracon* sp. 1, Uganda, Kibale (AY296642), *Ipobracon* sp. 2, Uganda, Kibale (AY296641), *Archibracon deliberator* Szépligeti, Benin (AY529702), *Sororarclibracon* sp. Africa (AY296645), *Sylvibracon* sp., Africa (AY296643).

FIELD SITE

Observations were made near Makerere University Biological Field Station, Kanyawara, Kibale National Park, West Uganda, in an area of montane rain forest that was lightly logged in 1960 (Area 14 in Struhsaker 1997).

OBSERVATIONS, RESULTS AND DISCUSSION

A large black and red female parasitic wasp was noticed 'drilling' into a dead trunk (6cm diameter) of a young 'forest mahogany' tree, *Trichilia dregeana* Sond. (Meliaceae), that appeared to have been felled during path clearing earlier in the year. The wasp, identified as a species of *Bathyaulax*, was collected and the point of ovipositor drilling noted and marked. Two days later a length of the dead tree was cut and taken to a more convenient site for dissection. This approximately 2m long stretch of the wood was found to be heavily bored by larvae of the longhorn beetle *Chromalizus fragrans* (Dalman) subspecies *cranchii* (White) (Cerambycidae: Cerambycinae: Callichromini); sometimes this subspecies is treated as a full species. The beetle is recorded by Duffy (1957) as being widely distributed in central and western equatorial Africa, viz. Angola, Democratic Republic of Congo (as Belgian Congo), Cameroons, Ghana (as Gold Coast) and Rio Muni. Its host plants are reported to include *Coffea canephora* Pierre ex Froehner (as *robusta* Linden) and *Teclea viridis* Verdoorn, but it has not previously been reported from any *Trichilia* species (Duffy 1957). Most Callichromini attack their host trees while they are still alive, supporting our assumption that the tree involved had been alive until fairly recently before we discovered it.

In total the borings included three with beetle pupae, two of which were extracted alive and reared for identification. In addition to these beetle pupae, three of the beetle pupation chambers contained par-



Fig. 1. Photographs of parasitoid cocoons found in *Chromalizus fragrans* pupation chambers: *Gabunia* sp. (Ichneumonidae: Cryptinae) on left, removed from cocoon; *Bathyaulax* sp. (Braconidae: Braconinae) pupa in cocoon on right.

asitoids. One contained a large parasitoid pupa at an advanced stage of development judging from its pigmentation within its reddish-brown silk cocoon, the second contained a large whitish larva within a reddish-brown cocoon within which there was also a reddish meconial pellet (Fig. 1 left), and the third contained a more slender, pale yellow parasitoid pupa within a pale yellow brown cocoon (Fig. 1 right). The beetle pupae and the parasitoid cocoons were all found in cells behind a hard, concave, white, rather crystalline deposit (probably a meconial material from the beetle larva) that sealed the chamber off from the rest of the boring.

The well-developed parasitoid from the red-brown cocoon emerged (though rather deformed) after approximately 2 weeks and was identified as *Gabunia* aff. *togoensis* Krieger (Ichneumonidae: Cryptinae), a species that is quite common in Kibale and which probably relies largely on vibra-

tional sounding to locate hosts (Quicke et al. 2003). The host remains associated with it show that it had attacked its host in the larval or pre-pupal stage.

DNA sequencing of the cocooned parasitoid larva in the reddish-brown cocoon and of the yellow parasitoid pupa revealed these to be a *Gabunia* species and a *Bathyaulax* species respectively. Some of the molecular data supporting the latter identification are shown in Fig. 2; the other sequence was identical to that obtained from the *Gabunia* aff. *togoensis* specimen whose behaviour was reported by Quicke et al. (2003). To date three *Bathyaulax* species, collectively from different parts of the Afrotropical Region, have been sequenced, and all share a very similar insert region (Fig. 2). Apart from that, the three sequences, which include the very morphologically aberrant *B. cyanogaster* Szépligeti, are virtually identical, though interspecific differences are also apparent.

Wasp	Gene fragment
<i>Bathyaulax</i> sp., Kibale	TATGGGTTACT----ACTACAG- TTAC --- T ----GTA-GT---GT-----GTATTGCC
<i>Bathyaulax</i> sp., Kenya	TATGGGTTACT--CTG CTACAA - TTAC --- T ----GTA-GTAC-GT-----GTATTGCC
<i>Bathyaulax cyanogaster</i>	TATGGGTTACT--CTACT ACAA - TTAC --- T ----GTA-GTACTGT-----GTATTGCC
<i>Monilobracon</i> sp.	TATGGGTTACT-----TTTACAC--CTTGTGTGTATT-----AT---GTATTGCC
<i>Latana keijua</i>	TATGGGTTACTATATGCATATATGCAC--TTGT--GTATGTA-TGT---TTAGTATTGCT
<i>Odontoscapus</i> sp.	TATGGGTTACTATTCTTTAATCGG-TC---TT-----A-----GTATTGCC
<i>Iphiaulax</i> sp.	TATGGGTTACT-----AC---TT---GTA-----GTATTGCC
<i>Merinotus</i> sp.	TATGGGTTACT-----AC---TT---GTA-----GTATTGCC
<i>Plaxopsis</i>	TATGGGTTACT-----AC---TT---GTA-----GTATTGCC
<i>Ipobracon</i> sp.1	TATGGGTTACT-----AC---TTA-T-GTA-----GTATTGCC
<i>Ipobracon</i> sp.2	TATGGGTTACT-----AC---TT---GTA-----GTATTGCC
<i>Archibracon deliberator</i>	TATGGGTTACT-----AC---TT---GTA-----GTATTGCC
<i>Sororarchibracon</i> sp.	TATGGGTTACT-----AC---TT---GTA-----GTATTGCC
<i>Sylvibracon</i> sp.	TATGGGTTACT-----AC---TT---GTA-----GTATTGCC

Fig. 2. By eye arrangement of part* of 28S D2 rDNA sequence from the Kibale specimens (adult and pupa) of *Bathyaulax*, plus two other congeners and various taxa of large braconines representing genera found at Kibale. Features unique to *Bathyaulax* are highlighted in bold face.
*, corresponding to part starting at position 23 in the alignment shown in Fig. 1 of Belshaw et al. (1998) and running into first box.

Previously *Bathyaulax* species have been reared on only three occasions (Quicke 1989). On two of these, they were reared from *Acacia* pods in Namibia (recorded as South West Africa) and in one of these two cases the host was reported as being a larval cerambycid. In the third known rearing, made in Kenya, the host was identified as the cerambycid beetle *Enaretta castelnaudi* Thomson (Cerambycidae: Lamiinae: Tetraopini) also on *Acacia*. *Enaretta castelnaudi* is widespread throughout the Afrotropical region and its larvae feed on the seeds of several *Acacia* species including *A. albida* Rojas, *A. hebeclada* DC and *A. stolonifera* Burch. (Duffy 1957). Thus *Bathyaulax* species appeared to be associated with hosts in *Acacia* seed pods, and the large arched terminal tarsal articles and slender claws of *Bathyaulax* species (Quicke 1981) could reasonably be interpreted as being adaptations to gripping these hard and smooth host substrates. However, no data are available for *Bathyaulax* species dwelling in moist tropical

forests where *Acacia* is effectively absent, though other pod-bearing trees are of course present. The present observations show that *Bathyaulax* species are not restricted to attacking hosts in pods though an exclusive association with Cerambycidae is still possible. It seems unlikely that the arched telotarsi would be of any special use in the species involved here as the hosts were inside a normal piece of wood, albeit one of a relatively hard type.

No meaningful key to species of *Bathyaulax* exists and therefore it is not possible to identify the species involved here. Although Fahringer (1928) provided keys, based very largely on the original literature sources rather than examination of specimens, he split members of the genus mostly between *Bathyaulax*, *Megagonia* Szépligeti and *Goniobracon* Szépligeti, and included within each of these members of other braconine genera with large antero-lateral areas on the 3rd metasomal tergite such as *Zaglyptogastra* Ashmead species, though these appear to be but distantly re-

lated to *Bathyaulax*. The list of species in Shenefelt's (1978) catalogue is therefore effectively meaningless. The type specimens of virtually all described species of tropical Braconinae have been examined by the senior author, along with all the original descriptions, and as a result approximately 35 species are now placed in *Bathyaulax* (see Quicke 1981, 1983, 1985a,b, 1991a, Quicke & van Achterberg 1990, Quicke & Koch 1990). Based on these observations, the species of *Bathyaulax* dealt with here appears to be new to science and will be dealt with in a forthcoming revision of the genus (Kaartinen & Quicke in prep.). Indeed, although revisions of genera of large and colourful ichneumonoids from the tropics often leads to no major increase in the total number of known species (e.g. El-Heneidy and Quicke 1991; Quicke 1991b; Chishti and Quicke 1994, 1996), much of the material collected by the authors in Kibale in 2002 and 2003 seems to be new, and it is possible that this represents a relatively distinct and very little studied ichneumonoid fauna (as also indicated by its cryptine ichneumonid fauna; Gavin Broad pers. comm.).

Trichilia P. Browne, the host tree genus including the widespread Afrotropical species involved here, is known for its very good, rather dense and close-grained wood that is widely used for making furniture and utensils, but is reported to be heavily attacked by wood-borers (Noad and Birnie 1989; Beentje 1994). Further, several species in this Afrotropical and Neotropical genus have been subject to intense investigation as a possible source of biologically active compounds, both as potential medical and potential crop protection agents. Further investigation of its borer and associated parasitoid systems will therefore be particularly interesting.

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Paper Wasps of the Genus *Polistes* in Eastern Lesser Sunda Islands (Hymenoptera: Vespidae)

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Abstract.—Social wasps of the polistine genus *Polistes* in the eastern part of the Lesser Sunda Islands (Sumba, Flores and Timor Islands) were examined based on the specimens recently collected by ourselves. The following four species are recognized: *P. (Gyrostoma) diabolicus*, *P. (G.) tenebricosus*, *P. (Polistella) callimorpha* and *P. (Polistella) sagittarius*. We include new records of *Polistes* wasps from Sumba Island. Nests and mature larvae of *P. diabolicus* and *P. callimorpha*, and males of *P. diabolicus* are described for the first time. New synonymies included are: *Polistes sulcatus* Smith, 1852, *P. hoplitus* de Saussure, 1853, *P. tenebricosus leopoldi* Bequaert, 1934, *P. tenebricosus nigrosericans* Bequaert, 1940, and *P. tenebricosus sibuyanensis* Bequaert, 1940, all under *P. tenebricosus* Lepeletier, 1836; and *P. sagittarius indonesicus* Bequaert, 1940, under *P. sagittarius* de Saussure, 1853.

Polistes Latreille, 1802, consisting of 205 species, is one of the largest genera in the social wasp subfamily Polistinae and is the only social wasp genus that has a cosmopolitan distribution (Carpenter 1996a). The genus is currently divided into four subgenera: nominate subgenus, *Polistella* Ashmead, 1904, *Gyrostoma* Kirby, 1828, and *Aphanilopterus* Meunier, 1888. The first three subgenera are, except for a few introduced species, restricted to the Old World, with the subgenus *Polistes* being mainly temperate, and *Polistella* and *Gyrostoma* being more tropical. *Aphanilopterus* is of the New World. While subgeneric taxonomy of *Polistes* has been rather well studied (van der Vecht 1972, Richards 1973, Kojima and Kojima 1988, Carpenter 1996b) and the four subgenera currently recognized are more or less well defined, species-level taxonomy of the genus, especially of the species in the Old World tropics, is still poorly resolved.

The Indonesian fauna of *Polistes* is, like that of other terrestrial arthropods, of spe-

cial interest from a biogeographical points of view. Twenty species so far recorded from Indonesia can be divided into five groups in terms of their distribution patterns: (1) species widely distributed from continental Asia to islands of Indonesia (*P. olivaceus* (DeGeer, 1773), *P. rothneyi* Cameron, 1900, *P. sulcatus* Smith, 1852, *P. tenebricosus* Lepeletier, 1836, *P. sagittarius* de Saussure, 1853, *P. stigma* (Fabricius, 1793)), usually represented by many local color forms; (2) species occurring only in the Malay Peninsula and Borneo Island (*P. meadeanus* (von Schulthess, 1913)); (3) species restricted to Java and Lesser Sunda Islands (*P. diabolicus* de Saussure, 1853); (4) those restricted to New Guinea Island, but often occurring also on its adjacent islands including the Moluccas (*P. tepidus* (Fabricius, 1775), *P. bambusae* Richards, 1978, *P. elegans* (Smith, 1859), *P. melanopterus* Cameron, 1911, *P. nigrifrons* Smith, 1859, *P. utakwae* Meade-Waldo, 1916), usually represented by island-specific color forms; and (5) species confined to small island(s)

in a restricted area (*P. burnuensis* Petersen, 1990, on Buru; *P. extraneus* Kirby, 1883, on Maru; *P. lateritius* Smith, 1857, on Ambon, Seram, and Saparua; *P. mertonii* du Buysson, 1913, on Aru; *P. callimorpha* de Saussure, 1853, on Timor; *P. simulatus* Smith, 1860, on Halmahera, Morotai, Obi, Bacan and Kayoa).

The eastern Lesser Sunda Islands include Sumba, Flores and Timor as major islands. The region should be important in understanding diversification and dispersal processes of terrestrial arthropods in the transition areas between the Oriental region and New Guinea and/or Australia. This could also be the case for *Polistes* wasps. Three species (*P. diabolicus*, *P. tenebricosus* and *P. sulcatus*) have so far been recorded from Flores, and *P. diabolicus* and *P. callimorpha* from Timor, while no *Polistes* species has been known from Sumba Island. Those records of *Polistes* species from Flores and Timor are based on research carried out more than 50 years ago (de Saussure 1853–58, du Buysson 1913, Bequaert 1934, von Schulthess 1935).

The present study discusses the taxonomy and distribution of *Polistes* wasps in these three islands based on adult wasps, nests and larvae collected during our recent research trip to the region.

MATERIALS AND METHODS

Field collection of the wasps and their nests was conducted in Sumba and Flores Island and the eastern part of Timor Island by us except FS during the period from 23 January to 3 February 2003.

Adult morphology was observed on pinned and dried specimens (including those emerging from the nests after nest collection) under a stereoscopic dissecting microscope. Male genitalia were dissected out, cleared in 10% KOH and observed in glycerin under a stereoscopic dissecting microscope.

Mature (=fifth instar) larvae were extracted from nest cells within one day after collection of nests, and then they were kept in 80% ethanol. Larvae were observed for their general appearance including coloration under a stereoscopic dissecting microscope. Some larvae were cleared in hot 10% KOH, heavily stained with acid fuchsin, dissected, and mounted on a glass slide in Canada balsam to observe microscopic structure under a compound microscope. Terminology of larval morphology follows Kojima (1998); first to third thoracic segment and first to tenth abdominal segment are abbreviated as T1–3 and A1–10, respectively.

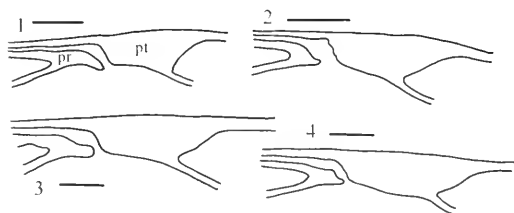
The nests collected were measured for the length and thickness of nest pedicel and the distance between opposite sides of a cell containing pupae or having trace of cocoon caps ("cell width") to the nearest 0.1 mm with vernier calipers. Thickness of the cell wall was measured with a micrometer to the nearest 0.01 mm.

Materials examined are deposited in the Museum Zoologicum Bogoriense and Natural History Collection at Ibaraki University. FS and JK are responsible for all arguments relating to the treatment of subspecies.

KEY TO *POLISTES* SPECIES IN WESTERN PART OF LESSER SUNDA ISLANDS

- 1 Clypeus not produced above anterior tentorial pits (Figs 5, 8). Pronotal fovea present. Prestigma about as long as or longer than half length of pterostigma (Figs 1, 2) 2 (subgenus *Gyrostoma*)
- Clypeus dorsally produced well above anterior tentorial pits (Fig. 13). Pronotal fovea, epicnemial carina and dorsal groove all absent. Prestigma short, distinctly shorter than half length of pterostigma (Figs 3, 4) 3 (subgenus *Polistella*)
- 2 Smaller species; forewing length 11–16 mm. Epicnemial carina and dorsal groove present (Fig. 11). Body black, extensively marked with bright-yellow *P. diabolicus*

- Larger species; forewing length 17–22 mm. Epinemial carina and dorsal groove both absent. Body ferruginous to orange-brown; first two metasomal terga extensively marked with yellow, or nearly entirely dark orange-brown *P. tenebricosus*
- 3 Smaller species; forewing length 8.5–11 mm. Gena proportionally narrow, in profile about 0.6 times as wide as eye in female. Body black, extensively marked with brown and yellow; wings transparent, with dark spot in marginal cell *P. callinorpha*
- Larger species; forewing length 18–20 mm. Gena wide, in profile about 0.9 times as wide as eye in female. Body ferruginous to dark brown, sometimes with dark orange-brown bands on second and/or first metasomal terga; wings entirely strongly fuscous
..... *P. sagittarius*



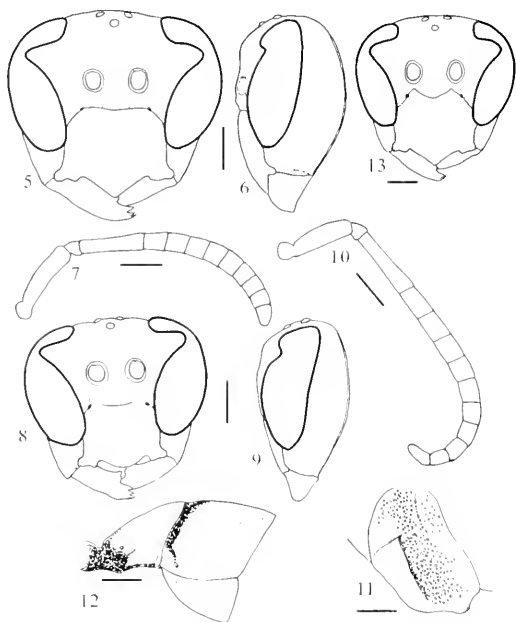
Figs 1–4. Prestigma (pr) and pterostigma (pt) of fore wing. 1, *Polistes diabolicus*. 2, *P. tenebricosus*. 3, *P. callinorpha*. 4, *P. sagittarius*. Scale bars: 0.5 mm.

DESCRIPTIONS AND TAXONOMIC NOTES ON EACH SPECIES

Polistes (Gyrostoma) diabolicus de Saussure, 1853

This species was originally described based on females from Java and Timor (de Saussure 1853–58: 68), and was recorded also from Lombok, Flores, and Kai Islands (von Schulthess 1935); its occurrence on Kai Islands needs confirmation as discussed later. The males, mature larvae and nests are described herewith for the first time; the present study also includes a new record of this species from Sumba Island.

Male.—Female characteristics that differ distinctly from that of males are given in brackets. Body length (head + mesosoma + first two metasomal segments) 12–14 [11.5–15.5] mm; forewing length 14–16.5 [12.5–16] mm. Head in frontal view (Fig. 8) about 1.2 times as wide as high [1.15; Fig. 5], about as wide as mesosoma excluding tegulae; inner eye margins barely convergent ventrally, distance between



Figs 5–13. Adult wasp. 5–12, *Polistes diabolicus*. 13, *P. sagittarius*. 5–7, 11, 13, female. 8–10, 12, male. 5, 8, 13, head, in frontal view. 6, 9, head, lateral view. 7, 10, left antenna. 11, mesepisternum. 12, first two metasomal segment, lateral view. Scale bars: 1 mm.

them at vertex about 1.1 times longer than distance at clypeus; clypeus nearly flat (Fig. 9), with slight truncation laterally [weakly convex; Fig. 6], rounded quadrate (Fig. 8) [transverse excluding ventral projection; Fig. 5], about 1.1 times wider than high, with ventral margin broadly rounded [produced ventrally]; gena proportionally narrower than in female, in profile (Fig. 9) little more than 0.8 times as wide as [nearly as wide as; Fig. 6] eye, slightly

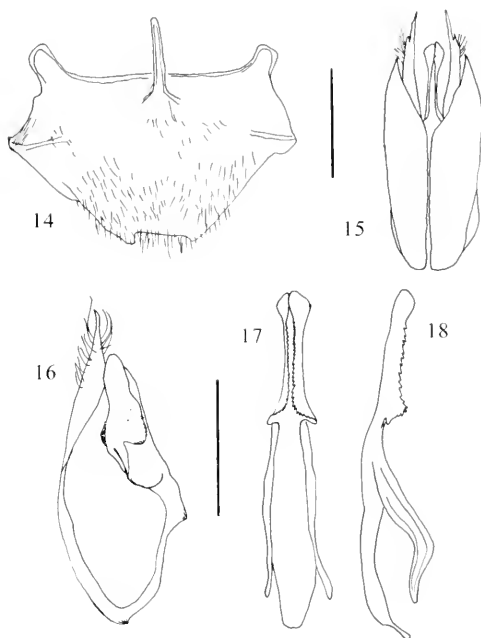
raised into blunt ridge just behind eyes [without such "ridge"]; ocelli arranged in nearly equilateral triangle, space between posterior ocelli about 1.3 times their diameter, and half as wide as distance to inner eye margin. Antenna (Fig. 10) not very different from that of female (Fig. 7); scape weakly swollen medially [slightly curved, not swollen medially], about 3.5 [4] times as long as wide; first flagellomere about 3.75 [3.3] times as long as its own apical width, distinctly longer than length of second and third flagellomeres combined [about equal to length of second to fourth flagellomeres combined]; terminal flagellomere very weakly curved, rounded apically, about twice as long as its own basal width [bullet shaped, about 1.25 times as long as its own basal width]; fifth to terminal flagellomeres with ill-defined flat area beneath [without tyloides or such flat areas].

Mesosoma about 1.7 times longer than wide. Epinemial carina weaker than in female. Propodeum with median depression shallow, with transverse striae; propodeal orifice narrowed above, but not pointed at dorsal end, about 2.5 times as long as wide.

First metasomal tergum slightly longer than wide, in profile (Fig. 12) abruptly swollen dorsally just behind basal slit for reception of propodeal suspensory ligament, then dorsally swollen gradually toward posterior margin; second tergum wider than long, little less than 1.5 times as wide as first tergum; second sternum more strongly convex than tergum.

Head feebly punctured, except for frons, where punctures are sparse but distinct; mesosoma with sparse punctures, except in unpunctured anteroventral area of mesepisternum; metapleura barely punctured, with a few, short, transverse striae ventrally; punctures on propodeum larger than those in other part, present between striae; metanotum barely punctured.

Terminal sterna as in Fig. 14; apical margin with a pair of subtriangular pro-



Figs 14–18. *Polistes diabolicus*, male. 14, terminal sterna, flattened. 15, genitalia, dorsal view. 16, inner aspect of paramere with digitus and volsella. 17, aedeagus, ventral view. 18, aedeagus, lateral view. Scale bars: 1 mm.

jections. Parameral spine (Figs 15, 16) thick, with tuft of hairs; lamina volsellaris sclerotized and separated from cuspis (jointed by membrane); digitus (Fig. 16) rather large, narrowed apically; rods forming aedeagus (Figs 17, 18) serrate ventrally, about 0.7 times as long as basal apodeme.

Black, extensively marked with bright yellow as follows: front of head below level of anterior ocellus, paired short band behind posterior ocelli, gena mostly, mandible except for dark brown teeth, pronotum, paired wide submedian bands and large spot beside tegula on mesoscutum, axilla, scutellum except for posterior margin, axillura, metanotum except for posterior margin, tegula except on inner margins, most of anterior part of and scrobal spot (sometimes reduced in size or absent) on mesepisternum [anteroventral part black, scrobal spot usually large in female], spot at anterodorsal corner of dor-

sal metapleura, spot at posterodorsal corner of ventral metapleura (sometimes absent), large lateral spots on propodeum, spot on propodeal valvula. Antenna yellow; scape black dorsally, pedicel black basally; flagellum ferruginous above or entirely ferruginous. Legs yellow; all coxae black dorsally; fore femur largely black; fore tibia and tarsi irregularly tinged with ferruginous, black dorsally; mid femur black dorsally; mid tibia largely ferruginous, with black markings; mid basitarsus black basally; hind femur black, with longitudinal yellow stripe; hind tibia black, with yellow spot near apical margin, hind basitarsus largely black. Metasoma dull yellow; basal part of first tergum, first sternum (often largely yellow), base of second tergum black [third and fourth terga sometimes with basal black bands].

Mature larva.—Cranial width 2.3–2.7 mm ($n = 21$). Cranium and mouthparts blackish brown; vertex slightly paler; ecdysial sulcus unpigmented; parietal band and ventral margin of labrum slightly paler. Venter of T1-3 except for posterior margins and anterior half of A1 venter dark brown.

Cranium in frontal view (Fig. 19) suboval, widest slightly below level of antennae, about 1.25 times as wide as high; in profile barely emarginate posteriorly (Fig. 20); front face including clypeus covered with sparse, short (about 0.07 mm long) setae. Outer one-third of parietal band reticulate. Ecdysial sulcus narrow, very shallow. Labrum (Fig. 22) narrowed where it joins clypeus, broadly and very shallowly emarginate medioventrally, with about 50 punctures bearing short (about 0.06 mm) setae in ventral half; ventral margin with a few, low conical papillae and sparse, minute spicules. Palate (Fig. 23) medially with about 20 small, conical papillae; ventral margin and ventrolateral part with sparse, minute spicules. Mandible (Fig. 24) with three teeth; median tooth nearly twice as long as inner and outer teeth. Maxilla covered with about 50 setae

(about 0.06 mm); upper surface with sparse, minute spicules; maxillary palpus (Fig. 26) simple in shape, nearly flat apically, with 3–6 apical sensilla; in one specimen, short additional palpus with apical sensillum present adjacent to right maxillary palpus (Fig. 27); galea simple in shape, more slender than maxillary palpus, with 2–4 apical sensilla. Prementum (Fig. 25) subcircular, with several setae in area dorsal to each labial palpus and about 50 setae in area ventral to labial pulpi; labial palpus (Fig. 28) simple, shorter than maxillary palpus, flat apically, with 4–6 apical sensilla. Postmentum (Fig. 25) small; surface with sparse setae.

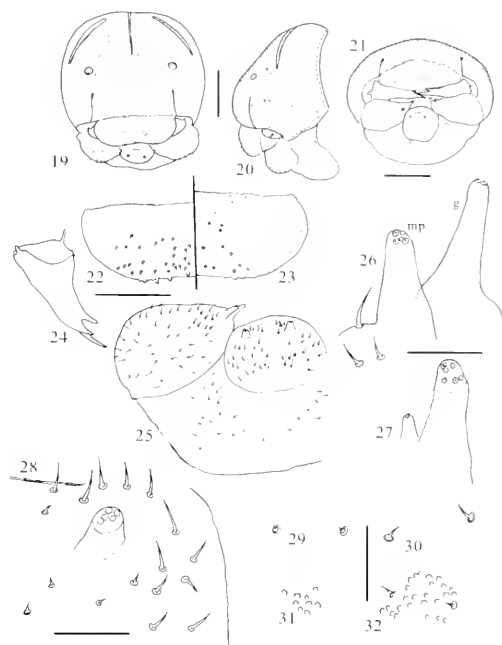
Body integument covered with scattered, short setae; setae on T1-3 venter (Fig. 29) shorter than those on other body surface (Fig. 30); dorsal lobes of abdomen bare. Spicules on body integument rounded apically (Figs 31, 32); T1-3 venter (except for posterolateral margins of T2 and T3) and A9 and A10 (except for anterior margin of each segment) lacking spicules. Second spiracle smaller than other spiracles, about 0.8 times as wide in diameter as others; spiracular atrium bare.

Nest.—Five nests were collected in Kupang, Timor Island (Table 1), of which PT-4 was before the appearance of pupae; others had produced adults from the nests. In all the four nests with pupae, “tandem brood” was recognized, that is, one and the same cell was occupied at the same time by a pupa (or rarely a mature larva) and an egg or a young larva, the phenomenon typically found in the subgenus *Gyrostoma* (Yamane and Okazawa 1977).

Three of the five nests (PT-2, -5, -6) were made on twigs of trees, PT-4 under eaves of a nipa house, and PT-3 under a leaf of an unidentified broad-leaf tree. Structural characters are as follows: comb nearly concentric, horizontal, and directed downward, bell-shaped with upper surface strongly convex in earlier stage of nest development (Fig. 33), more or less hat-

shaped in larger nests (Fig. 34), with lower surface (corresponding to open ends of cells) nearly flat, gray to brownish gray, but dark brown around pedicel attachment due to coating of salivary secretion of adult wasps. Pedicel single, shiny dark brown due to coating of salivary secretion, with longitudinal ridges (indicating that the thickening of pedicel is made not only by repeated coating of secretion but also by application of plant fibers), 4.1–7.1 mm ($n = 5$) long, 1.3–1.6 mm ($n = 5$) thick near mid-length, attached to periphery of first cell base, so that the pedicel is actually attached to the base of face shared by the first and second cells. Cells barely diverging toward open end, hexagonal in shape at open end when they are surrounded by neighboring cells; cell width, mean \pm SD = 5.8 ± 0.3 mm (range 5.3–6.4 mm, $n = 35$); cell wall 0.06–0.18 mm ($n = 5$) thick, made of long fibers, sometimes extended beyond cocoon caps to make excess space in which eggs were laid. Cocoon caps nearly white, slightly domed, usually projecting well beyond rim of cell, except in case of excess elongation of cell wall.

Adult wasps examined.—Flores: 1 ♀, 08°44'S 121°45'E, Detusoko, Ende, 26.i.2003, JK; 3 ♀ 2 ♂, 08°45'S 121°51'E, Wollowaru, Ende, 26.i.2003, JK. Sumba: 1 ♀, 09°42'S 119°53'E, Lewa, Sumba Timur, 30.i.2003, JK & RU (**NEW RECORD** for the island). West Timor: 4 ♀, 09°57'S 124°09'E, Batuputih, Timor Tengah Selatan, 1.ii.2003, JK (1 ♀, Nest#PT-6); 9 ♀, 09°59'S 124°01'E, Takari, Kupang, 1.ii.2003, JK (4 ♀, Nest#PT-5); 1 ♀, 10°06'S 123°50'E, Kupang Timor, Kupang, 1.ii.2003, JK; 1 ♀, 10°13'S 123°50'E (360m alt.), Amarasi, Kupang, 2.ii.2003, JK; 2 ♀, 10°06'S 123°50'E, Amarasi, Kupang, 2.ii.2003, JK; 26 ♀ 6 ♂, 10°12'S 123°40'E, Fenonisa, Central Kupang, 23.i.2003, JK (7 ♀, Nest#PT-3; 19 ♀ 6 ♂, Nest#PT-2); 1 ♀, 10°10'S 123°40'E, Penfui, Central Kupang, 23.i.2003, JK.



Figs 19–32. Mature larva of *Polistes diabolicus*. 19, head, frontal view. 20, head, lateral view. 21, head, ventral view. 22, labrum. 23, palate. 24, mandible. 25, maxilla, prementum and part of postmentum. 26, apical part of maxilla, showing maxillary palpus (mp) and galea (g). 27, galea. 28, labial palpus and structures around it. 29–32, setae and spicules on body integument (29, T3 venter; 30, A1 venter; 31, A3 venter; 32, T2 dorsum). Scale bars: 1 mm (19–21), 0.5 mm (22–25), 0.1 mm (26–32).

Polistes (Gyrostoma) tenebricosus Lepelletier, 1836

Polistes tenebricosus Lepelletier, 1836: 529.

Polistes sulcatus Smith, 1852: 38. **NEW SYNONYMY.**

Polistes hoplitus de Saussure, 1853, in de Saussure, 1853–1859: 55. **NEW SYNONYMY.**

Polistes tenebricosus var. *leopoldi* Bequaert, 1934: 9. **NEW SYNONYMY.**

Polistes tenebricosus var. (or subsp.) *nigrosericans* Bequaert, 1940: 266. **NEW SYNONYMY.**

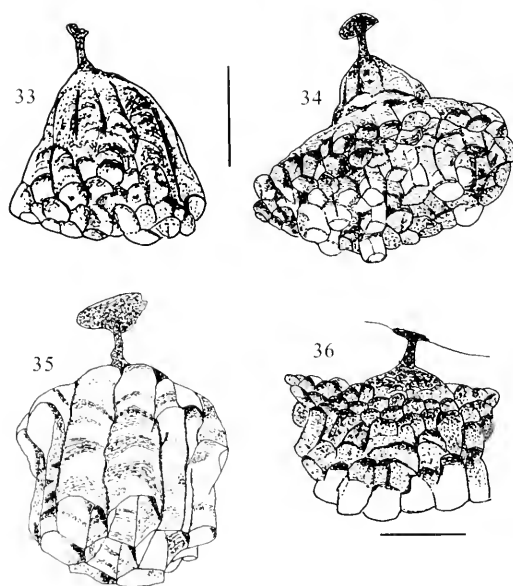
Polistes tenebricosus var. (or subsp.) *sibuyanensis* Bequaert, 1940: 266. **NEW SYNONYMY.**

Bequaert (1934) treated *P. sulcatus* Smith, 1852 as a variety of *P. tenebricosus*, the treatment followed by Das and Gupta (1983, 1989) but as a subspecies. Richards (1973) proposed the subgenus *Nygmopol-*

istes with *P. sulcatus* as the type species. Finally Starr (1992), following advice from Sô. Yamane as personal communication, mentioned that "there are distinct differences in the abdomen [=metasoma] and nest between specimens from Java and Taiwan . . . I tentatively treat the species found in Taiwan as *P. sulcatus*" (p. 123), the treatment followed by Carpenter's (1996a) checklist of *Polistes* species. According to Sô. Yamane (personal communication), the wasps from Sumatra [not Java] have the first metasomal tergum with the anterodorsal angle more sharply angled and the second metasomal sternum more strongly swollen ventrally than the wasps from Taiwan; nests are also different, that is, the nests of the wasps in Sumatra are hat-shaped, while those from Taiwan are bell-shaped. The specimens that we collected in Flores include wasps with both types of metasoma (Figs 37, 40), but they also include specimens that have metasomata of intermediate shapes (Figs 38, 39), incorporating the extremes. As shown for *P. diabolicus*, the nest shape may differ according to the size that a given nest can attain.

Bequaert (1934, 1940) recognized, based on color pattern, six local varieties (including *sulcatus*) in *P. tenebricosus*, all but "*sulcatus*" being currently treated as subspecies (see Carpenter 1996a); nominate subspecies, *hoplitus* de Saussure, 1853, *leopoldi* Bequaert, 1934, *nigrosericans* Bequaert, 1940, and *sibuyanensis* Bequaert, 1940. We concur that the subspecies category has no place in a phylogenetic system (Nixon and Wheeler 1990). Our observations showed that Yamane's grounds for separation of *sulcatus* are not upheld, and the "subspecies" of *P. tenebricosus* can be defined only by color patterns that intergrade, these having led us to synonymize all taxa treated as color varieties of *P. tenebricosus* by Bequaert (1934, 1940) under nominate *P. tenebricosus*.

Wasps collected on Sumba Island are so similar in structure to those from Flores



Figs 33–36. Nests. 33, 34, *Polistes diabolicus*. 35, *P. tenebricosus* from Sumba Island. 36, *P. callimorpha*. Scale bars: 20 mm (33, 34), 10 mm (35, 36).

that we should treat them as *P. tenebricosus*; **NEW RECORD** of this *Polistes* wasp from Sumba Island. On the other hand, they have a color pattern remarkably different from those from Flores and any other known color forms of *P. tenebricosus* as described below.

Color pattern of specimens from Sumba.—Brown to dark orange-brown, with following parts black: ill-defined spot around ocelli, lateral projections of clypeus (border ill-defined), mandibular teeth; flagellum except basal half of first flagellomere; anteroventral area of mesepisternum, spot on border between dorsal and ventral metapleura, most of ventral surface of mesosoma, ill-defined posteromedian spot on propodeum (markings on mesosoma sometimes reduced in size), basal parts of first and second metasomal terga, first sternum, basal part of second sternum, basal part of hind coxa, basal band of hind femur (often absent). First and second metasomal terga colored with bright yellow as follows (Figs 41, 42): most of posteroventral area of first tergum (anterior mar-

gin irregular and with fine, transverse, median, brown line);

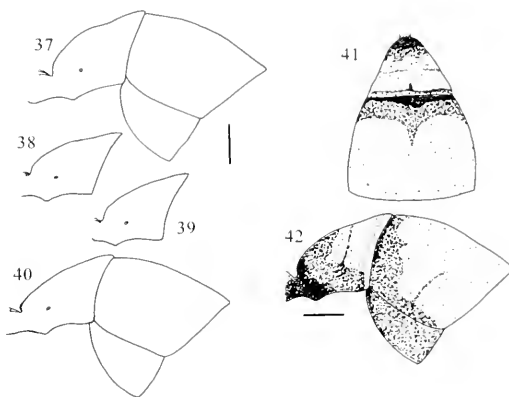
Mature larva.—Four mature larvae from two nests from Sumba were examined. Their coloration and structure were generally as those of *P. tenebricosus* from Luzon, the Philippines (Kojima 1984) and from Sumatra, Indonesia (Kojima and Yamane 1984).

Cranial width 3.1–3.4 mm ($n = 4$). Cranium and mouthparts blackish brown, but ventral margin of labrum often slightly paler; ecdysial sulcus, parietal band and center of antenna unpigmented. T1 venter largely dark grayish brown.

Structure (Figs 43–52) similar to that of *P. diabolicus*, but distinctly different in the following points: papillae on ventral margin of labrum and palate much reduced in size; galea (Fig. 48) with its apex slightly divided into four lobes, each of which has a small, apical sensillum (in one specimen, left galea with one lobe separated from the others by deep incision; Fig. 49); posterior margin of T1 venter with sparse spicules; T2–3 venter covered with dense spicules (Fig. 51); some spicules on T4–6 venter (Fig. 52) shaped ridge-like.

Nest.—Three nests were collected in Sumba Island; all were before the production of adults from the nests. Nest PS-1 was made on the upper surface of a limestone cave (about 1.5 m diameter) and had only eggs as immatures (Table 1). PS-2 and -3 were made close to each other (about 0.2 m apart from each other) under a roof of an outside kitchen; in both nests “tandem brood” was recognized.

Nest structure (Fig. 35) basically as that of *P. diabolicus* in early stage; comb bell-shaped, whitish-gray to gray in color, but brown to dark brown around pedicel attachment due to coating of salivary secretion; pedicel 5.1–7.7 mm ($n = 2$) long, 0.9–1.0 mm ($n = 3$) thick near mid-length; cell width 7.2–7.5 mm ($n = 3$); cell wall 0.04–0.10 mm ($n = 3$) thick; cocoon caps nearly white, barely domed, not produced beyond rim of cell.



Figs 37–42. Metasoma of *Polistes tenebricosus*. 37–40, wasps from Flores Island. 41–42, color pattern of a wasp from Sumba Island. 37, 40, 42, first and second metasomal segments, lateral view. 38, 39, first tergum, lateral view. 41, first two segments, dorsal view. Scale bars: 2 mm.

Adult wasps examined.—Flores: 2 ♀, 08°48'S 121°34'E, Baramari, Ende Selatan, 26.i.2003, JK; 2 ♀, 08°44'S 121°41'E, Detusoko, Ende, 26.i.2003, JK; 1 ♀, 08°47'S 121°25'E, Nangapenda, Ende, 25.i.2003, JK; 1 ♀, 08°45'S 121°34'E, Wolowaru, Ende, 26.i.2003, JK; 1 ♀, 08°51'S 121°41'E, Hotel Safari, Ende, 24.i.2003, JK. Sumba: 6 ♀, 09°42'S 119°53'E, Lewa, Sumba Timur, 30.i.2003, JK & RU (3 ♀, Nest#PS-2; 1 ♀, Nest#PS-3); 1 ♀, 09°55'S 120°39'E (120 m alt.), Umalulu, Sumba Timur, 29.i.2003, JK, Nest#PS-1; 1 ♀, 09°43'S 120°02'E (500 m alt.), Nggahariango, Sumba Timur, 30.i.2003, JK & RU.

Polistes (Polistella) callimorpha de Saussure, 1853

Since its original description based on females and male(s) from Timor (de Saussure 1853–1858: 71), this species has referred to only by du Buysson (1913: 228; from Kai Island) and in the checklist of *Polistes* species (Carpenter 1996a). This species is closely related to *P. stigma*, but can be distinguished from the latter by the head in dorsal view more strongly narrowed posteriorly behind eyes (Figs 53 vs. 54) and the propodeum not excavated (or

even slightly convex) in anterior half of its posterior face (very shallowly excavated medially in *P. stigma*). *Polistes stigma* occurs widely in the Oriental and Australian regions, represented by many local forms, but there are no records from Java and Lesser Sunda Islands (see Carpenter 1996a); we examined a female from Lombok Island (1♀, 08°32'S 116°15'E, Narmada, Lombok Barat, 7.xi.2000, J. Kojima), **NEW RECORD**, for comparison with *P. callimorpha*.

Mature larva.—Cranial width 2.2–2.4 mm ($n = 8$). Cranium (Fig. 55) grayish brown, with wide, transverse, whitish yellow band below level of antenna; mouthparts and body unpigmented.

Cranium in frontal view (Fig. 56) broadly rounded above, nearly parallel-sided ventral to level of antennae, about 1.3 times as wide as high; in profile (Fig. 57) shallowly emarginate posteriorly, with anterior margin bluntly angled near dorsal margin of clypeus. Integument of cranium, except for vertex and gena, covered with long (0.15–0.2 mm long) setae. Outer half of parietal band reticulate. Ecdysial sulcus narrow, very shallow. Antenna small, with three minute sensilla, two of which located very close to each other. Labrum (Fig. 58) narrowed where it joins clypeus, broadly and shallowly emarginate ventromedially, with about 50 setae; ventral margin with 5–6 elongate, conical papillae and sparse spicules. Palate (Fig. 59) with about 15 conical papillae medially; ventral and ventrolateral marginal areas with sparse spicules. Mandible (Fig. 60) with three teeth; median tooth short, less than one-third as long as outer and inner teeth, which sometimes have minute denticles (Figs 61, 62). Maxilla (Fig. 63) with about ten rather long setae in apical half; upper surface with minute spicules, which are arranged in rows; maxillary palpus (Fig. 64) simple in shape, elongate cone-shaped, with 3–5 apical sensilla; galea (Figs 63–66) irregular apically, divided into three lobes to varying degrees, with

apical sensillum on each lobe. Prementum circular (Fig. 63), with 6–9 setae in area dorsal to each labial palpus; area ventral to labial palpi with about 40 setae; labial palpus (Fig. 68) simple, shorter than maxillary palpus, flat apically, with four apical sensilla. Postmentum (Fig. 62) small, sparsely scattered with punctures.

Body integument covered with sparse, minute setae, except on A1–2 venter; setae on A1 venter long (0.2–0.25 mm long) (Fig. 69); setae on A2 venter short (about 0.03 mm; Fig. 70). Spicules on body integument ridge-shaped (Figs 69, 70), dense on anterior segments, becoming sparser on posterior segments; A9–10 without spicules. Dorsal lobes of abdomen lacking setae and spicules. First spiracle slightly larger than second one, which is about 1.4 times wider in diameter than succeeding ones.

Nest.—A nest (Fig. 36) made under main vein of a leaf of an unidentified broad-leaf tree at about 3 m from the ground was collected in a farmer's garden in Kupang, Timor Island. The nest had produced 12 adults judging from the presence of meconia.

Structural characters are as follows: comb (Fig. 36) rather irregular in shape, horizontal, and directed obliquely downward; upper surface (corresponding to cell base) slightly concave, except weakly convex area around pedicel attachment; comb color gray to brownish gray, with most of upper surface brown or dark brown around pedicel attachment due to coating of salivary secretion. Pedicel single, shiny blackish brown due to coating of salivary secretion, thickened exclusively by repeated coating of salivary secretion, 4.0 mm long, 0.8 mm thick near mid-length, attached subperipherally to comb. Cells slightly diverging toward open end, arranged generally regularly and hexagonal in shape at open end when they are surrounded by neighboring cells, but sometimes irregularly arranged, possibly due to diverging cell shape, in which they are

pentagonal or heptagonal at open end; cell width, mean \pm SD = 4.3 ± 0.5 mm (range 4.0–4.7 mm, $n = 9$); cell wall about 0.05 mm thick, made of long fibers. Cocoon caps pale brown, slightly domed, projecting beyond rim of a cell by 3.5–4.5 mm ($n = 10$), without application of blotch of plant fibers.

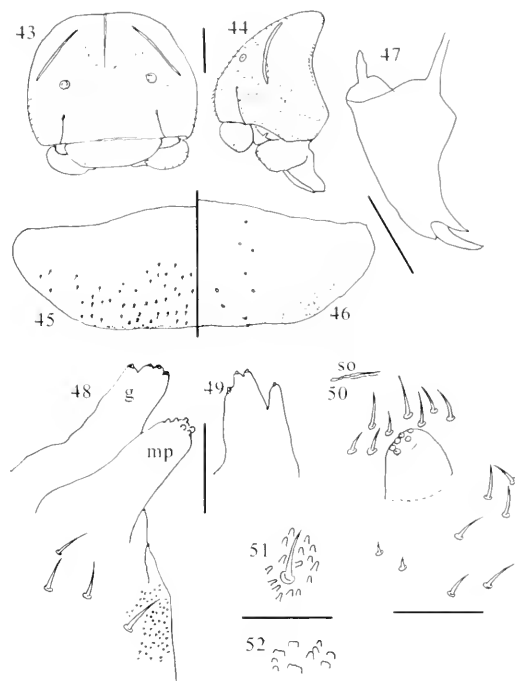
Adult wasps examined.—Sumba: 2♀, 09°43'S 120°02'E (500m alt.), Nggahaorian-go, Sumba Timur, 30.i.2003, JK; 2♀, 09°40'S 119°51'E, Sumba, Sumba Timur, 30.i.2003, JK (**NEW RECORD** for the island). West Timor: 3♀, 10°12'S 123°40'E, Fenonisa, Central Kupang, 23.i.2003, JK, Nest#PT-1; 1♀, 10°06'S 123°05'E, Kupang Timur, Kupang, 1.ii.2003, JK; 2♀, 10°13'S 123°50'E (360m alt.), Amarasi, Kupang, 2.ii.2003, JK; 2♀, 10°15'S 123°50'E, nr. Berherdi di Taman Raya, Kupang, 2.ii.2003, JK; 1♀, 09°57'S 124°09'E, Batuputih, Timur Tengah Selatan, 1.ii.2003, JK.

Polistes (Polistella) sagittarius de
Saussure, 1853

Polistes sagittarius de Saussure, 1853, in de Saussure, 1853–58: 56.

Polistes sagittarius var. (or subsp.) *indonesicus* Bequaert, 1940: 267. **NEW SYNONYMY**.

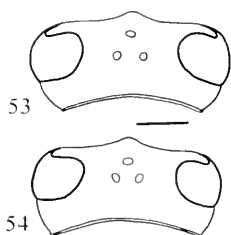
This species has been recorded from India, continental Southeast Asia and Palawan of the Philippines, and, in Indonesia, from Sumatra, Java, Bali and Sulawesi. Currently two color forms are recognized as subspecies: *P. s. sagittarius* and *P. s. indonesicus* Bequaert, 1940. Their differentiation is mainly based on color pattern of the first two metasomal terga, being mostly yellow or orange-yellow in *P. s. sagittarius* and entirely ferruginous in *P. s. indonesicus*. In the present field research, the species was collected only on Flores Island, **NEW RECORD**, and the specimens have a color pattern that generally matches that for *indonesicus*. Both forms (nominate *sagittarius* and *indonesicus*) have been recorded in Sumatra and Sulawesi (see Carpenter 1996a), and we have seen spec-



Figs 43–52. Mature larva of *Polistes tenebricosus* from Sumba Island. 43, head, frontal view. 44, head, lateral view. 45, Labrum. 46, palate. 47, mandible. 48, apical part of maxilla, showing maxillary palpus (mp) and galea (g). 49, galea. 50, labial palpus and structures around it including salivary opening (so). 51, 52, setae and spicules on T2 venter (51) and A4 venter (52). Scale bars: 1 mm (43, 44), 0.5 mm (45–47), 0.1 mm (48–52).

imens from Sumbawa Island (2♀1♂, 08°30'S 118°33'E, Bolo, Bima, 11.xi.2000, J. Kojima; **NEW RECORD** for the island) representing intermediate color patterns. The Museum Zoologicum Bogoriense houses a female from Sumba Island (Kanggar, 700 m, East Sumba, v.1925, Dammerman; **NEW RECORD** for the island), which also represents an intermediate color pattern. The taxon *indonesicus* is here-with synonymized under nominate *sagittarius* **NEW SYNONYMY**.

Adult wasps examined.—Flores: 2♀, 08°44'S 121°45'E, Detusoko, Ende, 26.i.2003; 5♀, 08°45'S 121°51'E, Wolowaru, Ende, 26.i.2003, JK; 1♀, 08°47'S 121°25'E, Nangapenda, Ende, 25.i.2003, JK; 1♂, 08°48'S 121°40'E, Ndona, Ende, 24.i.2003,



Figs 53–54. Female head, dorsal view. 53, *Polistes callimorpha*. 54, *P. stigma* from Lombok Island. Scale bar: 1 mm.

JK; 1 ♀, 08°40'S 121°20'E, Aesesa, Ngada, 25.i.2003, JK.

REMARKS ON THE *POLISTES* FAUNA IN EASTERN LESSER SUNDA ISLANDS

Two of the four *Polistes* species in the eastern part of Lesser Sunda Islands are undoubtedly of continental origin; for *P. tenebricosus* and *P. sagittarius*, Flores could be the extent of their eastward expansion. *Polistes sagittarius* is expected to occur on Lombok Island from which no records of this species are available. The Sumba population of *P. tenebricosus* represents a color pattern unique to this island. Sumba Island is known to harbor species or local forms endemic to the island, as illustrated

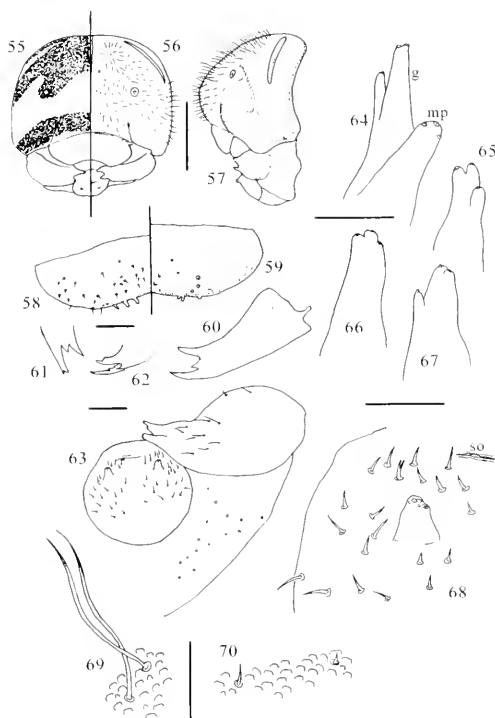
with some other social wasps (*Ropalidia*: van der Vecht 1962, Kojima and Carpenter 1997; *Vespa*: van der Vecht 1957, Carpenter and Kojima 1997).

The occurrence of *P. diabolicus* on Sumba Island and the fact that this species has not been recorded in the areas west of Java may suggest its Lesser Sunda origin. The present study also recorded *P. callimorpha* from Sumba Island, suggesting close zoogeographic relationships among Timor and Sumba and that this species may occur also on Flores Island. In this respect, the distribution pattern of *P. diabolicus* and *P. callimorpha* with occurrence in the eastern part of the Lesser Sunda Islands and Kai Islands but not in New Guinea or Aru Islands is rather puzzling. Kai Islands are much closer in their geographical location to Aru and New Guinea than to Timor. The social wasp fauna in Kai is so far known to comprise seven species, of which *Polistes tepidus* (Fabricius, 1775) and *P. elegans* (Smith, 1859) are undoubtedly New Guinean elements, and *P. stigma* and *Vespa affinis* (Linnaeus, 1764) are widely distributed in the Oriental and Papuan areas (see Carpenter 1996a, Carpenter and

Table 1. Biological data of *Polistes* nests examined in Timor Island (*P. diabolicus* and *P. calimorpha*) and Sumba Island (*P. tenebricosus*) in 2003.

Species and nest code	Date	Height from ground (m)	Number of*					
			cells	eggs	larvae	pupae	empty cells	females
<i>P. diabolicus</i>								
PT-2	23 Jan.	ca. 2.5	123	72 (30)	71 (4)	22	0	7<
PT-3	23 Jan.	ca. 3.5	65	50 (5)	28 (1)	7	0	7<
PT-4	1 Feb.	1.7	54	24	29	0	1	3<
PT-5	1 Feb.	2.4	54	26 (9)	26	10	1	4<
PT-6	1 Feb.	0.7	57	31 (13)	27	12	0	3
<i>P. callimorpha</i>								
PT-1	23 Jan.	ca. 3	102	68	25	9	2	6<
<i>P. tenebricosus</i>								
PS-1	29 Jan.	1.5	16	15	0	0	0	1
PS-2	30 Jan.	1.7	18	8 (2)	5	3	4	3
PS-3	30 Jan.	1.7	23	10 (2)	7	2	6	1

* Numerals in parentheses indicate the number of eggs of larvae present in pupal cells or cells containing mature larvae. When some females escaped at collection, the numbers of females collected are given with "<".



Figs 55–70. Mature larva of *Polistes callimorpha*. 55, 56, head, frontal view (55, marking pattern; 56, structure). 57, head, lateral view. 58, labrum. 59, palate. 60–62, mandible. 63, maxilla, prementum and part of postmentum. 64, maxillary palpus (mp) and galea (g). 66–67, shape variations of galea. 68, labial palpus and structures around it including salivary opening (so). 69, 70, setae and spicules on A1 venter (69) and A2 venter (70). Scale bars: 1 mm (55–57); 0.2 mm (58–63); 0.1 mm (64–70).

Kojima 1997). *Ropalidia unicolor* (Smith, 1859) is endemic to Kai Islands, but *R. socialis* (de Saussure, 1862), the species most closely related to *R. unicolor* (Saita & Kojima, 2005), occurs in Timor while any species closely related to *R. unicolor* have never been known from Aru or New Guinea. Thus the distributional pattern of *R. unicolor* and its closely related species is similar to that of *P. diabolicus* and *P. callimorpha*. Nevertheless, occurrence of the two *Polistes* species on Kai yet needs confirmation. Von Schulthess (1935: 298) listed Kai for the distribution of *P. diabolicus* without giving any data for specimens or references. Du Buysson (1913) briefly re-

ferred to color characteristics of specimens from Kai Islands under *P. callimorpha*, which generally match characteristics of Kai population of *P. stigma* described as a subspecies, *tualensis*, by Petersen (1987). Our knowledge of the social wasp fauna on the islands between Timor Island and New Guinea is still very poor, such knowledge should be the key to understanding diversification and dispersal processes of social wasps in the transition area between Oriental and Papuan areas.

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A New Genus and Species of Japanese Pompilinae (Hymenoptera, Pompilidae)

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Abstract.—The new genus *Hanedapompilus* Shimizu belonging to Pompilinae, Pompilidae, is described from Japan, based on the new species *H. yamagishii* Shimizu.

In studying wasps of the family Pompilidae from Japan, Shimizu has recently discovered a species of the subfamily Pompilinae that we have never seen in collections and that fails to fit into established genera. Although we have only nine females and four males of this species, it is remarkable that most of the specimens were collected by use of Malaise and emergence traps set in evergreen and deciduous forests in Honshu. In the present paper, we describe this new taxon as *Hanedapompilus* Shimizu, based on the new species *H. yamagishii* Shimizu.

The terminology of the wing veins and cells follows Day (1988). The following abbreviations are used for morphological terms: LID, lower interocular distance; MID, middle interocular distance; OOL, ocello-ocular line; POL, postocellar line; SMC, submarginal cell of forewing; UID, upper interocular distance.

The names of institutions in which type specimens will be deposited are abbreviated as follows: FSAG, Zoologie générale et appliquée, Faculté universitaire des Sciences agronomiques, Gembloux, Belgique; TMU, Department of Natural History, Graduate School of Science, Tokyo Metropolitan University, Tokyo, Japan.

Hanedapompilus Shimizu, new genus

Type species.—*Hanedapompilus yamagishii* Shimizu, by original designation and monobasic.

Diagnosis.—Distinguished from other genera of Pompilinae by the combination of the following nine characters: (1) female clypeus with apical margin slightly produced at both median and lateral portions (Fig. 1); (2) claws of both sexes cleft (Figs. 11, 23, 24); (3) arolium large, sometimes extending beyond tip of tarsal claws (Fig. 13); (4) orbicula small (Fig. 12); (5) orbicular pecten consisting of 7 diverging setulae that are much longer than orbicula (Fig. 12); (6) tarsal comb absent (Fig. 9); (7) underside of tarsomere V without spines; (8) male antenna short; and (9) male pronotum strongly narrowing in front (Fig. 16).

Description. Female.—*Head:* Mandible bidentate (excluding apical point). Labrum notched apically, but completely concealed by clypeus. Clypeus wider than LID (Fig. 1). Frons without prominence (Fig. 3). Antennal socket separated from frontoclypeal suture by more than half the diameter of the socket. Antenna slender; flagellomere I considerably longer than scape or pedicel, but shorter than UID.

Maxilla with palpomeres IV–VI much longer than palpomere III (Fig. 4). *Mesosoma*: Pronotum gradually narrowed in front, not swollen dorsolaterally; posterior margin angularly emarginate at middle. Postnotum well developed, more than half the length of metanotum. Propodeum never with well-defined declivity, smooth with coarse, suberect, silvery pubescence and long, erect, white hairs. *Legs*: Not strongly spinose. Claws with basal ray broadly truncate (Fig. 11). *Wings*: Forewing with pterostigma large, its base much longer than crossvein 2r-rs (Fig. 8). Marginal cell very long, acute apically, less than its own length from wing-tip. SMCs 2 and 3 four-sided. Last abscissa of vein M straight, but not reaching wing margin. Discal cell 2 long. Crossvein 2m-cu arising considerably more than half way from base of vein CuA₁ to wing margin. Hindwing with jugal lobe large, about half the length of subbasal cell, subtriangular. Crossvein cu-a originating considerably basad to point of separation of vein M+CuA, confluent with vein 1A, forming a long, smooth arc. *Metasoma*: Sternum 2 without transverse concavity. Sternum 6 somewhat compressed laterally, but without a median carina. Metasomal tergum 6 with several scattered, slender, flexible setae.

Male.—*Head*: Mandible unidentate. Apical margin of clypeus transverse (Fig. 14). Antenna short, not serrate, but each flagellomere slightly arched on ventral side (Fig. 17). *Legs*: Fore tarsomere V parallel-sided, not produced on inner margin. Fore tarsal claw asymmetrical; inner claw strongly curved, with basal ray large and rounded apically (Fig. 24). Outer fore tarsal claw (Fig. 23) and mid and hind tarsal claws cleft as in the female. *Metasoma*: Exposed portion of subgenital plate compressed laterally, but broadly flattened medially (Figs. 19, 20). *Genitalia*: Paramere extending far beyond apex of aedeagus (Fig. 18). Basal hooklets single.

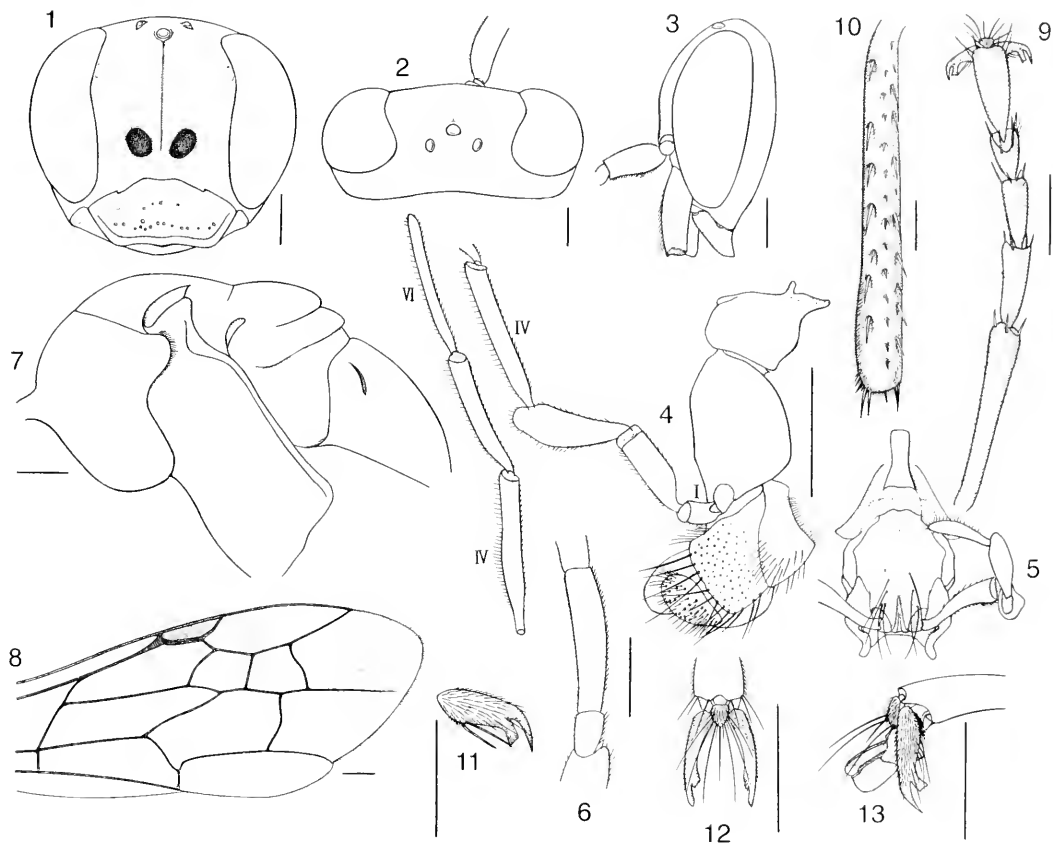
Biology.—Unknown.

Distribution.—Japan (Honshu).

Etymology.—From 'Haneda', in honor of the provider of specimens, and 'Pompilus', a generic name in the subfamily Pompilinae. Gender: masculine.

Discussion.—The prementum with a preapical circular, or heart- or spade-shaped membranous area is considered to be one of the synapomorphies of Pompilinae (Shimizu 1994). Although it does not have this feature (Fig. 5), *Hanedapompilus* apparently belongs to the Pompilinae because it bears the following features unique to this subfamily, i.e. (1) spines at apex of hind tibia of unequal length, more or less splayed out, and irregularly spaced (Fig. 10); and (2) dorso-inner portion of hind tibia with strong, at most six, spines in a row (Fig. 10). The genus also has other characteristics common in the Pompilinae but rare in the other subfamilies: (1) basal portion of forewing vein CuA₁ deflected downward (Fig. 8); (2) a cluster of basal hamuli strongly proximal to point of separation of vein C from vein Sc+R+Rs; (3) dorso-inner surface of hind coxa distinctly raised and somewhat lamellate; and (4) mid and hind femora with minute spines set in pits near apex.

This genus shows certain morphological similarities to *Agenioides*, such as (1) body and appendages black, with a white marking on hind tibia near base dorsally in both sexes and a white marking on metasomal tergum VII in the male; (2) propodeum with coarse, suberect, silvery pubescence; (3) legs not strongly spinose; (4) pterostigma large, at least 2.5× as long as high (Fig. 8); (5) orbicula small (Fig. 12); (6) orbicular pecten of about seven weak, divergent setulae (Fig. 12); (7) labrum notched apically; and (8) crossvein 2m-cu arising considerably more than half way from base of vein CuA₁ to outer wing margin (Fig. 8). Of these features, at least (4), (5), (6), and (8) are considered to be plesiomorphic (Shimizu 1994), and only (7) apomorphic in the Pompilidae. However, a labrum notched or cleft apically is found



Figs 1–13. *Hanedapompilus yamagishii* n. sp., holotype female. 1–3, Head (1, frontal view; 2, dorsal view; 3, lateral view). 4, Right maxilla, outer view. 5, Labium, posterior view. 6, Left antenna, dorsal view. 7, Mesosoma, lateral view. 8, Fore wing. 9, Left fore tarsus, dorsal view. 10, Right hind tibia, dorsal view. 11, Hind tarsal claw, outer view. 12–13, Pretarsus (12, dorsal view; 13, lateral view). Scale lines: 0.5 mm.

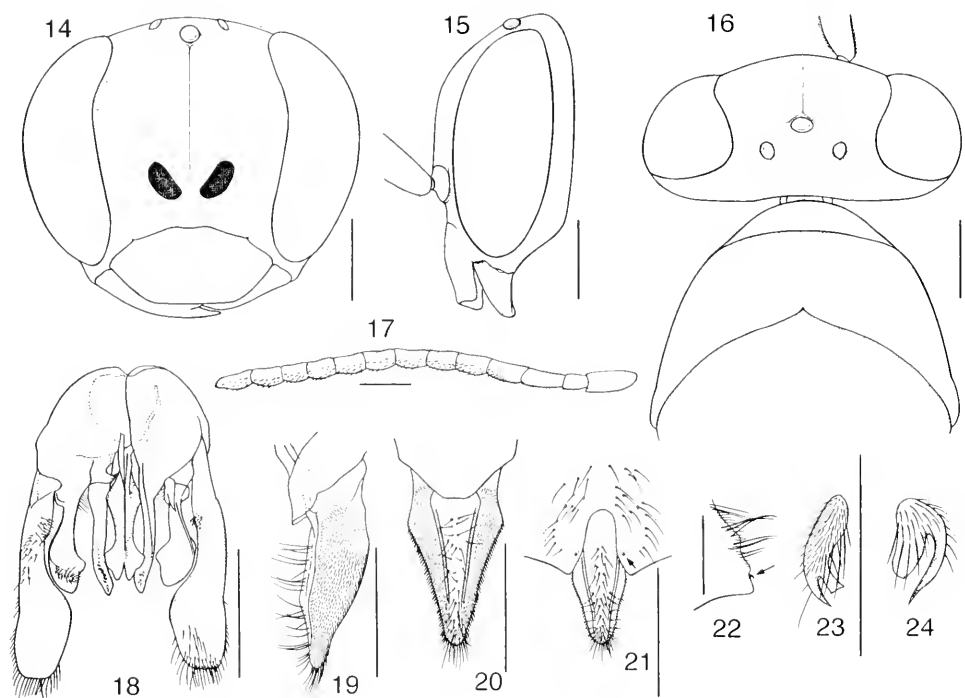
not only in *Agenioideus* but also in several other genera of Pompilinae, such as *Auospilus*, *Argyroclitus*, *Kyphopompilus*, *Pedinpompilus* and *Spuridiophorus*. Thus, it is not certain that *Hanedapompilus* is closely related to *Agenioideus*.

***Hanedapompilus yamagishii* Shimizu,
new species
(Figs. 1–24)**

In the following descriptions, measurements of the holotype are given in parentheses.

Female.—**Length:** Body 9.7–12.0 (11.0) mm; forewing 9.0–10.2 (9.9) mm. **Coloration:** Black. Inner orbit usually with a

small reddish-yellow spot at its dorsal third. Maxillary palpomeres IV–VI and labial palpomeres III–IV, together with apical portions of maxillary palpomere III and labial palpomere II more or less yellowish brown. Lower portion of pronotum pale brown. Hind tibia with a large ivory-white spot near base on dorsal side. Apical half of mandible and sometimes preapical narrow portion of clypeus ferruginous. Wings hyaline; forewing (Fig. 8) with preapical fascia narrow and obscure; inner fascia occupying marginal cell, apical portion of SMC2, SMC3, and apical portion of discoidal cell 2; hindwing slightly fuscous along outer margin. **Punc-**



Figs 14–24. *Haedapompilus yamagishii* n. sp., paratype male. 14–15, Head (14, frontal view; 15, lateral view). 16, Head and pronotum, dorsal view. 17, Left antenna, outer view. 18, Genitalia (left half, ventral view; right half, dorsal view). 19–20, Subgenital plate (sternum VIII) (19, lateral view; 20, ventral view). 21, Sterna VI and VIII, ventral view. 22, Sternum VI, lateral view. 23, Outer claw of fore tarsus, outer view. 24, Inner claw of fore tarsus, outer view. Arrow = lateral hook. Scale lines: 0.5 mm.

tation: Body almost devoid of punctures. **Pubescence and setae:** Body and appendages covered with comparatively long, silvery-white pubescence, which is dense on lower frons, clypeus and posterolateral portion of propodeum. Gena, postgena, propleuron, fore coxa, lateral sides of propodeum and metasomal tergum I with grayish white hairs long and abundant. Vertex, pronotum, scutellum, metanotum, mid and hind coxae, lateral side of metasomal tergum II, and median portion of sternum I with short gray hairs. Metasomal tergum VI and sterna II–VI with sparse, brown setae. **Head:** 1.1–1.2 (1.1)× as broad as long. Vertex slightly convex between eye tops (Fig. 1). Frons in lateral view (Fig. 3) gently convex above, feebly concave below antennal sockets, with median line fine from antennal base to ante-

rior ocellus. Antennocular line (anterior margin of frons in dorsal view) feebly inclined from antennal base toward eye (Fig. 2). Inner orbits convergent distinctly above but feebly below; MID 0.55–0.58 (0.55)× head width. UID:MID:LID = 7.4–7.8:10:9.1–9.6 (7.6:10:9.3). Ocelli forming obtuse triangle. POL:OOL = 1:0.64–0.90 (1:0.74). Clypeus 2.0–2.2 (2.1)× as broad as long, elevated above level of lower frons, with comparatively large, preapical setiferous pores; apical rim not depressed, alutaceous and mat. Malar space much shorter than half the length of antennal pedicel. Gena in dorsal view strongly receding (Fig. 2), in profile 0.4–0.6 (0.5)× eye width. Antenna thin and long; flagellomeres I and II in a ratio of 10:7.1–7.5 (10:7.2); flagellomere I feebly curved outward, thickest near middle (Fig. 6), 4.5–4.9 (4.5)×

as long as thick, $0.73\text{--}0.87$ (0.83) \times as long as UID. *Mesosoma*: Pronotum steeply sloping anteriorly (Fig. 7). Mesoscutum in profile convex, with parapsidal lines very fine; posterolateral margin slightly raised. Scutellum projecting above level of mesoscutum, considerably compressed laterally. Postnotum depressed between metanotum and propodeum, $0.42\text{--}0.60$ (0.60) \times as long as metanotum at midline, with a few faint transverse striae anteriorly. Metapleuron and propodeum subpolished. Propodeum with slope even but steep (Fig. 7), without median groove. *Legs*: Tarsomeres I–IV with short sparse spines on under side. Fore tarsomeres I–IV devoid of spines on inner and outer sides, except for short spines at apex of each tarsomere (Fig. 9). Hind tibiae dorsally with spines roughly in three lines; spines in the middle line much shorter than the other spines (Fig. 10). Longer spur of hind tibia exceeding two-thirds of hind tarsomere I. *Wings*: Forewing venation as shown in Fig. 8. SMC2 narrowed on vein Rs by $0.71\text{--}0.78$ (0.71) \times its length on vein M, receiving crossvein 1m-cu at apical $0.29\text{--}0.36$ (0.31). SMC3 $0.95\text{--}1.1$ (1.1) \times as long as SMC2 on vein M, narrowed on vein Rs by $0.39\text{--}0.60$ (0.56) \times its length on vein M, receiving crossvein 2m-cu near middle. Crossvein cu-a originating at point of separation of vein M+CuA.

Male.—*Length*: Body $6.5\text{--}8.4$ mm; forewing $5.6\text{--}7.8$ mm. *Coloration*: Similar to the female. Ventral sides of scape, pedicel, and flagellomere I more or less brown. Scape with an apical yellow spot on ventral side. Pronotal tubercle and metasomal tergum 7 with an ivory-white marking. *Head*: $1.2\times$ as broad as long. Antennocular line more convex than in the female (compare Fig. 16 with Fig. 2). Inner orbits distinctly convergent above and below (Fig. 14). MID $0.56\text{--}0.59\times$ head width. UID: MID:LID = $7.8\text{--}8.0$: 10 : $7.8\text{--}8.3$. POL:OOL = 1 : $0.54\text{--}0.70$. Clypeus $2.0\text{--}2.1\times$ as broad as long. Gena in dorsal view thinner and more strongly receding than in the female

(compare Fig. 16 with Fig. 2), in profile $0.2\text{--}0.3\times$ eye width. Flagellomeres I and II in a ratio of 10 : $8.9\text{--}10$. Flagellomere I $2.2\text{--}2.4\times$ as long as thick, $0.37\text{--}0.44\times$ as long as UID. *Metasoma*: Apical margin of sternum VI with a U-shaped, deep emargination (Fig. 21); a pair of hooks very small (Figs. 21, 22). Subgenital plate with a pair of strong sublateral carinae; portion between the carinae almost flattened, with several erect setae (Fig. 19, 20). *Genitalia* (Fig. 18): Paramere broadened in apical third. Digitus volsellaris broadened and club-shaped apically. Parapenial lobe parallel-sided, curved downward apically, extending slightly beyond apex of aedeagus. Aedeagus gradually constricted subapically, with a large, arrowhead-shaped terminal. *Wing*: Forewing SMC2 narrowed on vein Rs by $0.76\text{--}0.81\times$ its length on vein M, receiving crossvein 1m-cu at apical $0.30\text{--}0.42$. SMC3 $0.93\text{--}1.1\times$ as long as SMC2 on vein M, narrowed on vein Rs by $0.40\text{--}0.51\times$ its length on vein M.

Type material.—Holotype ♀, Mount Sanage, Aichi, Evergreen Forest, Malaise Trap, 11–17.ix.1992, T. Kanbe (TMU). Paratypes: 1♀, Yamanaka, Takahama-cho, Fukui, 30.vi.2000, S. Inoue (TMU); 1♀, same data except for date, 16.viii.2001 (TMU); 1♀, Katsumi, Obama-shi, Fukui, 15.viii.2002, S. Inoue (TMU); 1♀, same locality as holotype, Deciduous Forests, Emergence Trap, 14–20.viii.1992, K. Shima (TMU); 1♀, Seto, Tougoku, Aichi, Evergreen Forest, Malaise Trap, 3–9.VIII.1997, M. Kenmotsu (FSAG); 1♂, Seto, Johkoji, Aichi, Evergreen Forest, Malaise Trap, 29.VIII.2000, C. Mizuno & N. Suzuki (FSAG); 1♀, Toyota, Sanage, Aichi, Evergreen Forests, Malaise Trap, 10.vi–16.vi.2002, Mizue Kiyota (TMU); 2♀1♂, same data except for date, 22.vii–28.vii.2002 (TMU); 1♂, same data except for date, 19.viii–25.viii.2002 (TMU); 1♂, same data except for date, 2.ix–8.ix.2002 (TMU).

Etymology.—In honor of the provider of specimens.

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References in the text should be (Smith 1999), without a comma, or Smith (1999). Two articles by a single author should be (Smith 1999a, 1999b) or Smith (1999a, 1999b). For multiple authors, use the word "and," not the symbol "&" (Smith and Jones 1999). For papers in press, use "in press," not the expected publication date. The Literature Cited section should include all papers referred to in the paper. Journal names should be spelled out completely and in italics.

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